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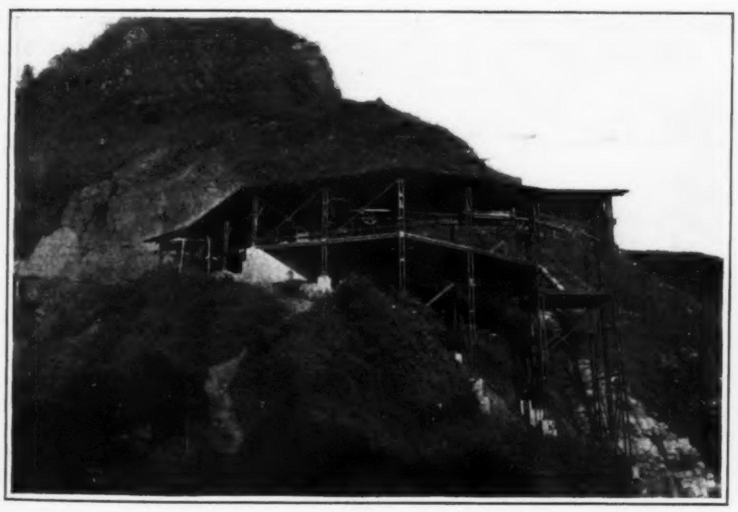
LOAD OF SAWN TIMBER DESCENDING TO THE VALLEY.

SECTION OF CABLEWAY BETWEEN PLATEAU AND STATION I.



THE FIRST ANGLE STATION SHOWN ON THE PROFILE.

A LOAD OF LOGS IN TRANSIT TO THE VALLEY.

SOME COMPLICATED CONSTRUCTION WAS NECESSARY TO CARRY THE CABLE AROUND A HORIZONTAL ANGLE.

CURIOUS TOPOGRAPHY OF THE COUNTRY AT ANGLE STATION I.

A WIRE ROPEWAY FOR GERMAN EAST AFRICA [See Page 72.]

The New Science of Geography*

The Modern Geographer's Task

By A. J. Herbertson of the University of Oxford

When we fix our attention on parts of the earth, and ask what is a natural unit, we are hampered by preconceptions. We recognize species, or genera, families or races as units—but they are abstract rather than concrete units. Speaking for myself, I should say that every visible concrete natural unit on the earth's surface consisting of more than one organic individual is a geographical unit. It is a common difficulty not to be able to see the wood for the trees; it is still more difficult to recognize that the wood consists of more than trees, that it is a complex of trees and other vegetation, fixed to a definite part of the solid earth and bathed in air.

The family, the species and the race are abstract ideas. If we consider them as units, it is because they have a certain historical continuity. They have not an actual physical continuity as the component parts of an individual have. Concrete physical continuity is what differentiates the geographical unit. We may speak of a town or state as composed of people, but a complete conception of either must include the spacial connections which unite its parts. A town is not merely an association of individuals, nor is it simply a piece of land covered with streets and buildings; it is a combination of both.

In determining the greater geographical units, man need not be taken into account. We are too much influenced by the mobility of man, by his power to pass from one region to another, and we are apt to forget that his influence on his environment is negligible except when we are dealing with relatively small units. The geographer will not neglect man; he will merely be careful to prevent himself from being unduly influenced by the human factor in selecting his major units.

Some geographers and many geologists have suggested that land forms alone need be taken into account in determining these geographical units. Every different recognizable land form is undoubtedly a geographical unit. A great mountain system, such as that of western North America, or a vast lowland, such as that which lies to the east of the Rocky Mountains, is undoubtedly a geographical unit of great importance, but its subdivisions are not wholly orographical. The shores of the Gulf of Mexico can not be considered as similar geographically to those of the Arctic Ocean, even if they are morphologically homologous. I wish to lay great stress on the significance of vegetation to the geographer for the purposes of regional classification. I do not wish to employ a biological terminology nor to raise false analogies between the individual organism and the larger units of which it is a part, but I think we should do well to consider what may be called the life or movement going on in our units as well as their form. We must consider the seasonal changes of its atmospheric and of its water movements, as well as the parts of the earth's crust which they move over and even slightly modify. For this purpose a study of climatic regions is as necessary as a study of morphological regions. The lowlands of the Arctic area are very different from those at or near the tropics. The rhythm of their life is different, and this difference is revealed in the differences of vegetation.

By vegetation I mean not the flora, the historically related elements, but the vegetable coating, the space-related elements. Vegetation in this sense is a geographical phenomenon of fundamental importance. It indicates quality—quality of atmosphere and quality of soil. It is a visible synthesis of the climatic and edaphic elements. Hence the vast lowlands of relatively uniform land features are properly divided into regions according to vegetation—tundra, pine forest, deciduous forest, warm evergreen forest, steppe and scrub. Such differences of vegetation are full of significance even in mountainous areas.

The search after geographical unity—after general features common to recognizable divisions of the earth's surface, the analysis of these, their classification into types, the comparisons between different examples of the type—seem to me among the first duties of a geographer. Two sets of maps are essential—topographical and vegetational—the first giving the superficial topography and as far as possible its surface irregularities, the latter indicating quality of climate and soil.

Much has been said in recent years—more particularly from this presidential chair—on the need for reliable topographical maps. Without such maps no others can be made. But when they are being made it would be very easy to have a general vegetational map compiled. Such maps are even more fundamental than geological maps, and they can be constructed more rapidly and cheaply. Every settled country, and more particularly every partially settled country, will find them invaluable if there is to be any intelligent and systematic utilization of the products of the country.

The geographer's task I am assuming is to study environments, to examine the forms and qualities of the earth's surface, and to recognize, define and classify the different kinds of natural units into which it can be divided. For these we have not as yet even names. It may seem absurd that there should be this want of terms in a subject which is associated in the minds of most people with a superfluity of names. I have elsewhere suggested the use of the terms major natural region, natural region, district and locality to represent different grades of geographical units, and have also attempted to map the seventy or eighty major natural regions into which the earth's surface is divided, and to classify them into about twenty types. These tentative divisions will necessarily become more accurate as research proceeds, and the minor natural regions into which each major natural region should be divided will be definitely recognized, described and classified. Before this can be done, however, the study of geomorphology and of plant formations must be carried far beyond the present limits.

At the opposite end of the scale, that is, in the geographical study of localities, good work is beginning to be done. Dr. H. R. Mill, one of the pioneers of geography in England, has given us in his study of southwest Sussex an admirable example of a geographical monograph proper, which takes into account the whole of the geographical factors involved. He has employed quantitative methods as far as these could be applied, and in doing so has made a great step in advance. Quantitative determinations are at least as essential in geographical research as the consideration of the time factor.

The geomorphologist and the sociologist have also busied themselves with particular aspects of selected localities. Prof. W. M. Davis of Harvard has published geomorphological monographs which are invaluable as models of what such work should be. In a number of cases he has passed beyond mere morphology and has called attention to the organic responses associated with each land form. Some of the monographs published under the supervision of the late Prof. Ratzel of Leipzig bring out very clearly the relation between organic and inorganic distributions, and some of the monographs of the Le Play school incidentally do the same.

At present there is a double need. Research may take the form, in the first place, of collecting new information, or, in the second place, of working up the material which is continually being accumulated.

The first task—that of collecting new information—is no small one. In many cases it must be undertaken on a scale that can be financed only by governments. The ordnance and geological surveys of our own and other countries are examples of government departments carrying on this work. We need more of them. We need urgently a hydrographical department, which would co-operate with Dr. Mill's rainfall organization. It would be one of the tasks of this department to extend and coordinate the observations on river and lake discharge, which are so important from an economic or health point of view that various public bodies have had to make such investigations for the drainage areas which they control. Such research work as that done by Dr. Strahan for the Exe and Medway would be of the greatest value to such a department, which ought to prepare a map showing all existing water rights, public and private.

We shall see how serious the absence of such a department is if we consider how our water supply is limited, and how much of it is not used to the best advantage. We must know its average quantity and the extreme variations of supply. We must also know what water is already assigned to the uses of persons and corporations, and what water is still available. We shall have to differentiate between water for the personal use of man and animals, and water for industrial purposes. The actualities and the potentialities can be ascertained and should be recorded and mapped.

In the second direction of research—that of treating from the geographical standpoint the data accumulated, whether by government departments or by private initiative—work has as yet hardly been begun.

The topographical work of the ordnance survey is the basis of all geographical work in our country. The survey has issued many excellent maps, none more so than the recently published half-inch contoured and hill-shaded maps with colors "in layers." Its maps are not all above criticism; for instance, few can be obtained for the whole kingdom having precisely the same symbols. It has not undertaken some of the work that should have been done by a national cartographic service, for instance, the lake survey. Nor has it yet done what the geological survey has done—published descriptive accounts of the facts represented on each sheet of the map. From every point of view this is a great defect; but in making these criticisms we must not forget (*a*) that the treasury is not always willing to find the necessary money, and (*b*) that the ordnance survey was primarily made for military purposes, and that the latest map it has issued has been prepared for military reasons. It has been carried out by men who were soldiers first and topographers after, and did not necessarily possess geographical interests. The ideal geographical map, with its accompanying geographical memoir, can be produced only by those who have had a geographical training. Dr. Mill, in the monograph already referred to, has shown us how to prepare systematized descriptions of the one-inch map sheets issued by the ordnance survey.

At Oxford we are continuing Dr. Mill's work. We require our diploma students to select some district shown on a sheet of this map for detailed study by means of map measurements, an examination of statistics and literature which throw light on the geographical conditions, and, above all, by field work in the selected district. Every year we are accumulating more of these district monographs, which ought, in their turn, to be used for compiling regional monographs dealing with the larger natural areas. In recent years excellent examples of such regional monographs have come from France and from Germany.

The preparation of such monographs would seem to fall within the province of the ordnance survey. If this is impossible, the American plan might be adopted. There the geological survey, which is also a topographical one, is glad to obtain the services of professors and lecturers who are willing to undertake work in the field during vacations. It should not be difficult to arrange similar co-operation between the universities and the ordnance survey in this country. At present the schools of geography at Oxford and at the London School of Economics are the only university departments which have paid attention to the preparation of such monographs, but other universities will probably fall into line. Both the universities and the ordnance survey would gain by such co-operation. The chief obstacle is the expense of publication. This might reasonably be made a charge on the ordnance survey, on condition that each monograph published were approved by a small committee on which both the universities and the ordnance survey were represented.

The information which many other government departments are accumulating would also become much more valuable if it were discussed geographically. Much excellent geographical work is done by the admiralty and the war office. The meteorological office collects statistics of the weather conditions from a limited number of stations; but its work is supplemented by private societies which are not well enough off to discuss the observations they publish with the detail which these observations deserve. The board of agriculture and fisheries has detailed statistical information as to crops and live stock for the geographer to work up. From the board of trade he would obtain industrial and commercial data, and from the local government board vital and other demographic statistics. At present most of the information of these departments is only published in statistical tables.

Statistics are all very well, but they are usually published in a tabular form, which is the least intelligible of all. Statistics should be mapped and not merely be set out in columns of figures. Many dull blue books would be more interesting and more widely

*Abstracted from a paper read before the British Association for the Advancement of Science.

used if their facts were properly mapped. I say *properly* mapped because most examples of so-called statistical maps are merely crude diagrams and are often actually misleading. It requires a knowledge of geography in addition to an understanding of statistical methods to prepare intelligible statistical maps. If Mr. Bosse's maps of the population of England and Wales in Bartholomew's survey atlas are compared with ordinary ones the difference between a geographical map and a cartographic diagram will be easily seen.

The coming census, and to a certain extent the census of production, and probably the new land valuation, will give more valuable raw material for geographical treatment. If these are published merely in tabular form they will not be studied by any but a few experts. Give a geographer with a proper staff the task of mapping them in a truly geographical way and they will be eagerly examined even by the man in the street, who can not fail to learn from them. The presentation of the true state of the country in a clear, graphic and intelligible form is a patriotic piece of work which the government should undertake. It would add relatively little to the cost of the census and it would infinitely increase its value.

The double lack—the lacunæ in the information and the absence of adequate geographical treatment of such material as there is—makes the task of studying the huge natural divisions which we call continents a very difficult and unsatisfactory one. For several years in Oxford we have been trying to gather together the material available for the study of the continents and to make as accurate maps as is possible for geographical purposes. We have adopted uniform scales and methods, and by using equal area projection we have obtained comparative graphic representations of the facts. We hope before the end of the year to issue maps of physical features, vegetation and rainfall of each continent and other maps for the world. These are being measured, and I hope will yield more reliable quantitative information about the world and its continents than we possess at present.

With such quantitative information and with a fuller analysis of the major natural regions it ought to be possible to go a step further and to attempt to map the economic value of different regions at the present day. Such maps would necessarily be only approximations at first. Out of them might grow other maps prophetic of economic possibilities. Prophecy in the scientific sense is an important outcome of geographical as well as of other scientific research. The test of geographical laws as of others is the pragmatic one. Prophecy is commonly but unduly derided. Mendelyeff's period law involved prophecies which have been splendidly verified. We no longer sneer at the weather prophet. Efficient action is based on knowledge of cause and consequence, and proves that a true forecast of the various factors has been made. Is it too much to look forward to the time when the geographical prospector, the geographer who can estimate potential geographical values, will be as common as and more reliable than the mining prospector?

The day will undoubtedly come when every government will have its geographical-statistical department dealing with its own and other countries—an information bureau for the administration corresponding to the department of special inquiries at the board of education. There is no geographical staff to deal geographically with economic matters or with administrative matters. Yet the recognition of and proper estimation of the geographical factor is going to be more and more important as the uttermost ends of the earth are bound together by visible steel lines and steel vessels or invisible impulses which require no artificial path or vessel as their vehicle.

The development of geographical research along these lines in our own country could give us an intelligence department of the kind, which is much needed. If this were also done by other States within the empire, an imperial intelligence department would gradually develop. Thinking in continents, to borrow an apt phrase from one of my predecessors, might then become part of the necessary equipment of a statesman instead of merely an after-dinner aspiration. The country which first gives this training to its statesmen will have an immeasurable advantage in the struggle for existence.

Our universities will naturally be the places where the men fit to constitute such an intelligence department will be trained. It is encouraging, therefore, to see that they are taking up a new attitude towards geography, and that the civil service commissioners, by making it a subject for the highest civil service examinations, are doing much to strengthen the hands of the universities. When the British Association last met in Sheffield geography was the most despised of school subjects, and it was quite unknown in the universities. It owed its first recognition as a subject of university status to the generous financial support of the Royal Geographical Society and the brilliant teaching of Mr. Mackinder at Oxford. Ten years ago schools of geography were struggling into existence at Oxford and Cambridge, under the auspices of the Royal Geographical Society. A single decade has seen the example of Oxford and Cambridge followed by nearly every university in Great Britain, the University of Sheffield among them. In Dr. Rudmore Brown it has secured a traveler and explorer of exceptionally wide experience, who will doubtless build up a department of geography worthy of this great industrial capital. The difficulty, however, in all universities is to find the funds necessary for the endowment, equipment and working expenses of a geographical department of the first rank. Such a department requires expensive instruments and apparatus, and, since the geographer has to take the whole world as his subject, it must spend largely on collecting, storing and utilizing raw material of the kind I have spoken of. Moreover, a professor of geography should have seen much of the world before he is appointed, and it ought to be an important part of his professional duties to travel frequently and far. I have never been able to settle to my own satisfaction the maximum income which a department of geography might usefully spend, but I have had considerable experience of working a department with an income not very far above the minimum. Till this year the Oxford School of Geography has been obliged to content itself with three rooms and to make these suffice not merely for lecture-rooms and laboratories, but also for housing its large and valuable collection of maps and other materials. This collection is far beyond anything which any other university in this country possesses, but it shrinks into insignificance beside that of a rich and adequately supported geographical department like that of the University of Berlin. This fortunate department has an income of about £6,000 a year and an institute built specially for its requirements at a cost of over £150,000, excluding the site. In Oxford we are only too grateful that the generosity of Mr. Bailey, of Johannesburg, has enabled the school of geography to add to its accommodation by renting for five years a private house, in which there will temporarily be room for our students and for our collections, but where we can never hope to do what we might if we had a building specially designed for geographical teaching and research. Again, Lord Brassey and Mr. Douglas Freshfield, a former president of this section, have each generously offered £500 toward the endowment of a professorship if other support is forthcoming. All this is matter for congratulation, but I need hardly point out that a professor with only a precarious income for his department is a person in a far from enviable position. There is at present no permanent working income guaranteed to any geographical department in the country, and so long as this is the case the work of all these departments will be hampered and the training of a succession of competent men retarded. I do not think that I can conclude this brief address better than by appealing to those princes of industry who have made this great city what it is to provide for the geographical department of their university on a scale which shall make it at once a model and stimulus to every other university in the country and to all benefactors of universities.

The Famous Star No. 61 Cygni*

By Arthur K. Bartlett.

The star known to astronomers as No. 61 Cygni, famous as being the first to have its distance determined by Bessel in 1838, and long believed to be the nearest to us of any in the heavens, is favorably situated for observation in midsummer at a convenient hour in the evening. At the end of July it may be seen to good advantage just east of the zenith at 9 o'clock on every clear evening, and directly overhead about one hour later. Though a faint and inconspicuous star, it may be located by averted vision, even in full moonlight, if one knows just where to look for it.

Owing to its faintness, the star 61 Cygni is not an attractive object, and being only of the fifth magnitude, it is just visible to the naked eye, but on account of its past history and the important observations associated with it, the star is regarded with special interest by astronomers, though it is not a notable body in other respects, or one that would excite curiosity or easily engage the attention of an ordinary observer.

The star is located in the constellation Cygnus, the Swan, known also as the "Northern Cross," which is a conspicuous figure in the Milky Way, and is visible in mid-summer exactly overhead, about three hours after sunset. The star No. 61 Cygni, being faint and unattractive, is identified with much difficulty, but any person who is familiar with the constellations may easily locate it by completing the parallelogram of which the stars Alpha, Gamma and Epsilon are at the other three corners. The stars Sigma and Tau form a little triangle with No. 61, which is the faintest of the three. Seen with a good telescope, No. 61 is also a fine "double star," the components being of the same magnitude, and their distance apart is about 20″ of arc, so that a low magnifying power will easily separate them.

The magnitude of a star does not form a reliable guide to its distance, size and actual brilliancy, and the faint star 61 Cygni is nearer to us than the peerless "Dog Star," Sirius, though it is nearly seven magnitudes smaller and sends to us nearly 600 times less light. No. 61 Cygni is the nearest star in the northern hemisphere of the sky, and next to Alpha Centauri, a bright, first magnitude star in the southern heavens, never visible in our latitude, it is the nearest star, so far as known, of all those that have been studied by astronomers. Its exact distance has never been determined, but is believed to be at least twice that of Alpha Centauri, which is 275,000 times the earth's distance from the sun, or 25 trillion miles. Through this space light itself, which travels at the rate of 186,380 miles per second, and would encircle the earth eight time in a single second, requires more than four years to pass.

It is a remarkable fact that no other stars, even of the first magnitude, are found to be so near as this. Most of those which have been measured have distances from five to ten times as great, and beyond the latter limit the distance becomes immeasurable by any known method. Seen from Alpha Centauri, the earth's orbit would appear the same as a circle six-tenths of an inch in diameter viewed at the distance of one mile, and this is the nearest star at present known to astronomers.

For many years 61 Cygni was supposed to be the second nearest star, but recently another small star, known in the catalogue as 21,185 Lalande, has been found to be a little nearer than 61 Cygni, which is more than half a light year nearer than Sirius, the brightest star in the heavens, while 21,185, a small star of the sixth magnitude, is more than a year and a half nearer. According to the late Prof. Simon Newcomb, the parallax of 61 Cygni is 0″ .39, and its luminosity is equal to about one-tenth that of the sun, while the parallax of 21,185 is 0″ .46, and its luminosity is 5-1,000th that of the sun.

The star 61 Cygni is located in a famous region of the sky, where the Milky Way is remarkably bright and where may be seen the dark, oval patch known as the "Northern Coal Sack," which is plainly visible to the naked eye. In this same part of the sky, within the constellation Cygnus, a wonderful "new star" appeared in the year 1876 which afterwards apparently changed into a nebula or "star cloud" and was an object of much attention with a very interesting history, while only a short distance west may be seen the bright star Vega, in Lyra, the Harp, toward which it is believed the sun, with its entire family of planets, meteors and comets, is journeying at the rate of 300 million miles every year.

* *The Monthly Register of the Society for Practical Astronomy.*

A New Grapevine Pest in France

Although vine-growing has been favored in France by the recent good weather, the crops are threatened by a new insect, the cochylis, which appears in certain regions. It is a minute moth whose larvæ feed on the flowers or fruit of the grapevine. The insects multiply very rapidly, according to M. Maissonneuve, the female laying 150 eggs on the average. When there are but 30 females in a vineyard, the first generation gives 4,500 insects, the second 675,000, etc. As there are two laying periods in each season, the ravages of the insect are greatly to be feared, even within a short time. As to the remedy against the cochylis, Prof. Cazeneuve, a well-known authority, considers that neither nicotine nor lead arsenate solutions are good for destroying the larvæ, as the insects penetrate inside the flower and they cannot be reached. He is making tests with a powerful insecticide, pyridine, for this purpose. It gives off vapors for several hours which are likely to penetrate into the retreats of the larvæ and thus destroy them. This substance is not expensive and only a 0.2 per cent solution is needed.

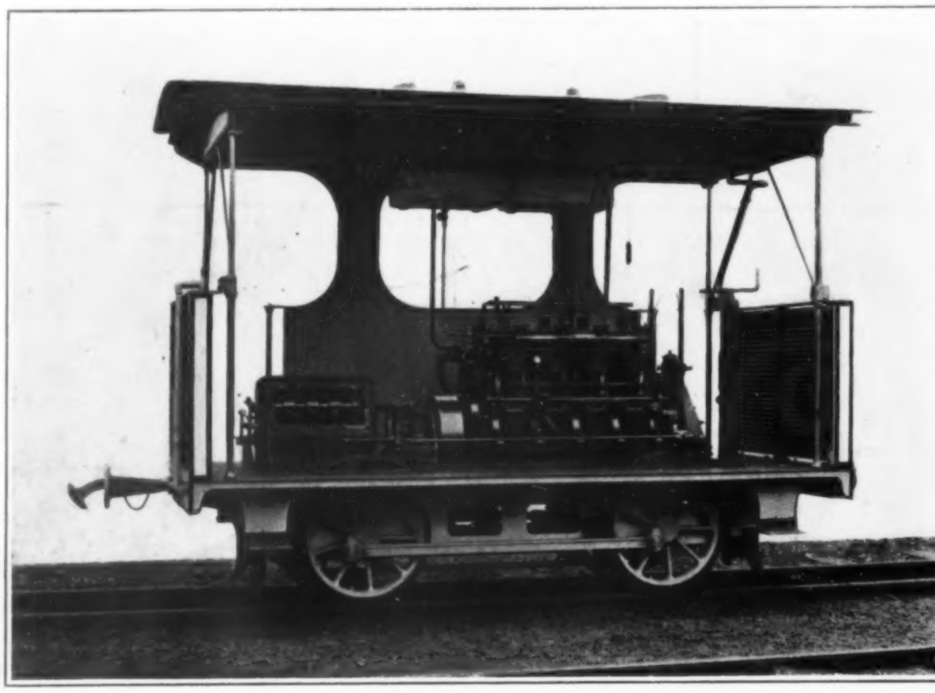
We learn from the Trinidad *Royal Gazette* that beginning July 1st, standard time, four hours later than Greenwich mean time, was officially adopted in the colonies of Trinidad and Tobago. This change was part of the programme of adopting uniform time throughout the British West Indies and British Guiana.

A Kerosene Oil Tractor for a Narrow-gage Native State Railway in India

By F. C. Cushman

The kerosene oil tractor which is illustrated in the accompanying photograph has recently been constructed by Messrs. Nasmyth Wilson & Company, Limited, of the Bridgewater Foundry, Patricroft, Manchester, England, for service on one of the 2-foot 6-inch gage native state railways in India. The following is a table of the general dimensions: Extreme length over buffers, 15 feet 7 inches; width over platform, 5 feet 7 inches; height from rail level, 9 feet 7½ inches; gage, 2 feet 6 inches; wheel base, 6 feet; wheels, 2 feet 6 inches diameter; steel frames, ⅝ inch thick, 2 feet 1 inch between; buffers from rail level, 2 feet 2 inches.

The engine was supplied by Messrs. L. Gardner & Sons, of Patricroft, and is of 30 horse-power, running at 750 revolutions per minute, with four cylinders vertical type, using ordinary commercial paraffin, with high tension magneto started by a detachable handle on the footplate and fitted with a silencer. A radiator is carried at either end of the tractor, each composed of a large number of small horizontal tubes, as illustrated on the photograph, and connected together with a large tank, constructed in and attached to the roof of the car. Additional tank accommodation is arranged on the roof for the storage of paraffin, and also for water. The tractor itself weighs in working order about seven tons, and is capable of a speed of 25 miles per hour on the level. It will draw a load of 18 to 20 tons up an incline of 1 in 150. The gear is of cast steel and a range of four speeds both forward and reverse is provided, all the gear wheels being case-hardened, and running in an oil bath. A special interlocking arrangement has been arranged whereby the reversing lever cannot be operated until the gear wheels are put into a neutral position. A powerful friction clutch is supplied, operated by a foot pedal on the footplate, and this is also interlocked with the brake gear, so as to prevent the clutch being thrown into the gearing while the brake was screwed down. The brake is the usual adjustable locomotive type, fitted with hand pillar and screw, and is applied to all four wheels through cast iron blocks. The drive is transmitted to one axle only by bevel gearing, but both wheels are coupled with coupling rods, thus insuring the full adhesive power of the tractor. The wheels and axles are of the usual locomotive type with gun metal axle boxes and bearings, and special arrangements are made for full lubrication. The car is fitted with a detachable roof constructed of teak and sheet plating, with an air space in between. A locomotive type of whistle is fitted to the engine exhaust. The buffers are of the central type with automatic coupling device.

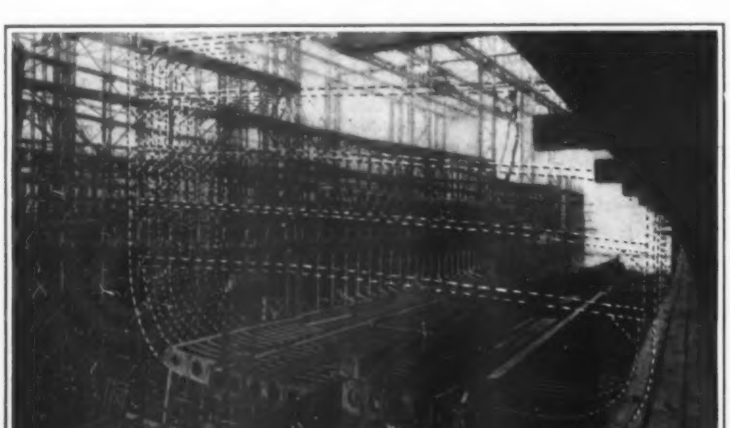


KEROSENE TRACTOR FOR NARROW-GAGE STATE RAILWAY IN INDIA

The Foundation Wall of a Giant Steamship

The construction of the foundation of a heavy building one hundred feet in height is a matter of no little importance, even when the edifice is being erected upon the solid rock of mother earth; but when, in place of unyielding rock, the structure must rest upon and within the turbulent waters of the storm-troubled ocean, the problem becomes immediately complicated. If to this be added the fact that our structure one hundred feet in height, instead of being fifty or one hundred, is nearly one thousand feet in length, and when we remember that its main points of support are constantly shifting, being sometimes near the ends and sometimes chiefly at the center, we can understand that the designing of this structure then is a very complicated matter indeed.

By way of illustration, we offer two pictures showing the construction, at the Vulcan Shipbuilding yards, of the largest steamship in the world, the "Europa" of the Hamburg-American line. The overall length of this ship will be 885 feet, and her beam 96 feet, and from her keel to the roof of her topmost deckhouse will be approximately 100 feet. We have spoken of the "foundation" of the vessel, and if such a term can be applied to a floating structure, it must refer, of course, to that complicated and elaborate cellular structure which is known as the double bottom, the construction of which is shown very clearly in our engraving. It consists essentially of an inner and outer skin of steel plating, placed six feet apart, with the inclosed space divided longitudinally and laterally by a series of plate-steel girders. Among these the most important, of course, is the central longitudinal member, which in the illustration is seen just to the left of the standing figure. Extending across the ship at intervals of a few feet is a series of transverse plate-steel girders which begin to taper as the turn of the bilge is reached, and curve upwardly, reducing in size as they extend up the sides of the ship to finish at the topmost plate-steel deck. Each of these transverse floor members, with its vertical extensions, is known as a frame, and it can be seen that there is here a general approximation



Constructing the Double Bottom of the "Europa" at Stettin. Length, 885 Feet; Beam, 96 Feet; Net Tonnage, 50,000 tons.

Keelson and Frame of "Europa," the New Hamburg-American Liner. The Figure Is Standing on the Outer Skin of Ship. To His Right and Behind Him, a Frame.

THE FOUNDATION WALL OF A GIANT STEAMSHIP

to the construction of the human frame and that of all vertebrate animals, the central keel answering to the backbone and the transverse framing to the ribs. At intervals of, say, eight to eleven feet, according to the height required between decks, a series of strong steel girders is thrown across from side to side of the vessel, one at each frame, and strongly riveted to the ribs, the connection being greatly stiffened by means of large knee plates—triangular plate-steel members, which are riveted to the deck beams and to the frames.

At intervals along the length of the ship, transverse steel walls are built up from the double bottom to above the water line of the ship, thus dividing her whole length into a series of separate water-tight compartments. It should be mentioned that a water-tight steel deck is laid from end to end of the ship upon each line of deck beams, and it can be seen that these steel decks and the bulkheads together serve not only to prevent the passage of water from one deck to another, but to separate each deck into a number of imprevious water-tight compartments.

Returning to our description of the double bottom, it should be mentioned that the frames of the flooring required 1,100 steel plates, each nearly 50 feet in length, and that in addition to the central keelson, there are ten other longitudinal plates which extend between the frames throughout the whole length of the floor, being strongly riveted thereto at every point of intersection. The "Europa" will have a net tonnage of 50,000, and in addition to a maximum capacity of 4,250 passengers, she will have accommodations for a crew of about one thousand men.

A New Steam Meter

By Robert Grimshaw

In these days the progressive manufacturer insists on having his coal, water and electricity, and even his steam, measured or weighed with the same accuracy and quite as much as a matter of course as his gas. It can not be said that any of the meters at present on the market and in use are absolutely reliable and exact—neither for that matter are the ordinary scales in common use; but at least an approximate measurement is obtainable, which will serve for purposes of comparison. Of steam meters there are but few, and these are not so well known as the water and gas meters; but they are improving each year in adaptability and accuracy, and what is also of importance, in cheapness and durability.

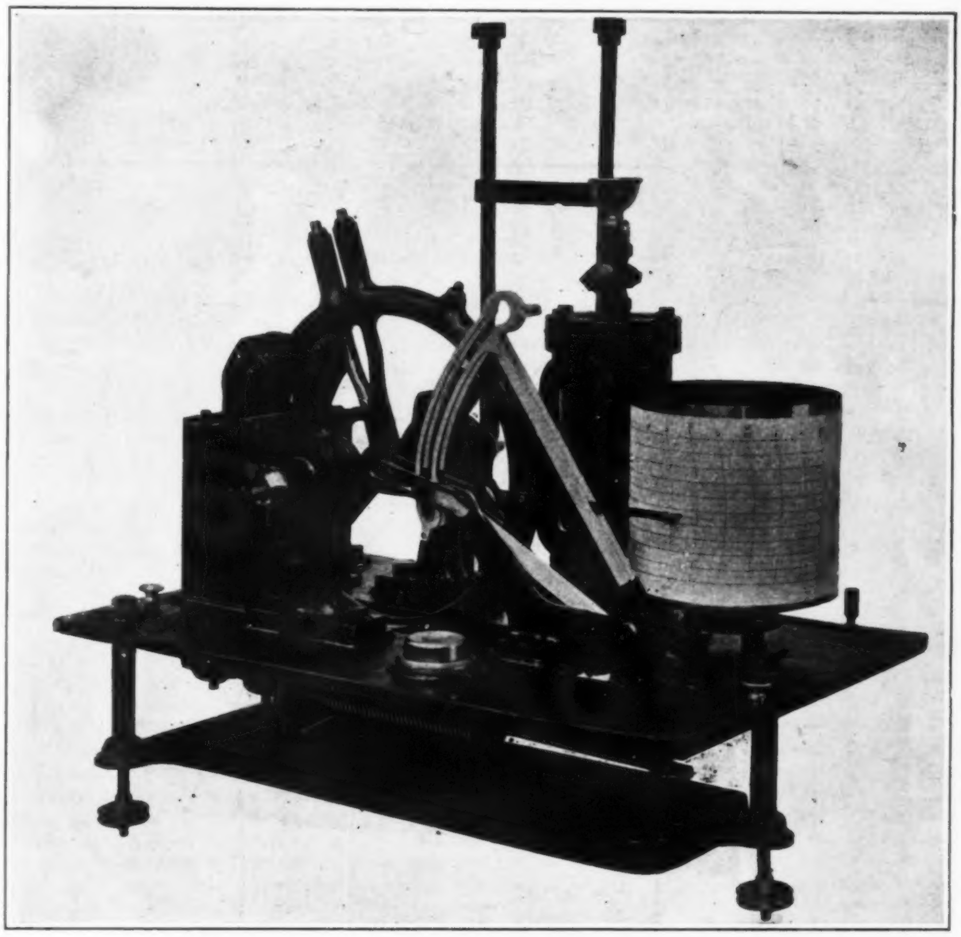
The registering steam meter here illustrated, made by the Apparate-Bauanstalt Paul de Bruyn, of Düsseldorf, consists essentially of a throttling disk built into the steam pipe, between two flanges, and a registering apparatus. The throttle consists of a cast-iron plate, 3 centimeters (1.17 inches) thick, provided with a hole of known diameter. On a cast-iron plate, which can be brought into exact horizontal position by means of two adjusting screws and a level, there are screwed two bearings, in which the measuring apparatus proper, resting on knife edges, turns easily. This part is made of cold-drawn tubing, the bore of which is divided transversely at the fulcrum by a partition; the under portion is filled with mercury, so that there is on each side of the partition a semi-cylindrical space bounded below by the mercury. Each of these spaces is in connection through the hollow trunnions with one of two pipe lines running to the steam pipe, and opening into the same, one on each side of the throttle-disk. The registering pencil is moved directly by the oscillating piece; its fulcrum is mounted in such manner that it can be moved by means of a slotted curved link, which is connected with a pressure piston playing in oil.

The operation of the apparatus is as follows: The throttle disk in the pipe line causes a reduction in pressure. The pressure before and behind the disk is measured; the difference of these two pressures, which is directly proportional to and dependent on the amount of steam flowing by, is the basis of calculation. The fall of pressure, caused by the presence of the disk, is barely noticeable, and exerts no influence on the working of the plant. The two pressures are conveyed by the two tubes which connect the apparatus with the measuring device to the two hollow spaces in the oscillator. The mercury in the two compartments of this latter rises to a height proportional to the pressures acting upon it. This shifts the center of gravity of system and causes the oscillator to tilt over, until the forces which cause the quicksilver to rise are in equilibrium.

The movement of the oscillator is conveyed to a two-armed lever at one end of which the vibrator is attached, while the other bears a pencil. Under the cast-iron base there is a pressure piston, which, when the pressure in the pipe-line varies, is moved to and fro, in a manner definitely controlled by a properly proportioned tension spring. The movement of this piston is conveyed to a link, which shifts the fulcrum of the pencil, so that this makes a trace varying in accordance with the varying quantity of steam. As the cross-sections of the vibrating piece are so chosen that the pencil always stands at the same point for the same quantity of steam, the diagram made on the drum paper gives the quantity of steam passed, in kilograms. The pipe connections, which are only ¼ inch in diameter, are kept full of water, and therefore remain cool.

The apparatus can be introduced in either a vertical or a horizontal steam-pipe line.

Seven tests ranging from 4 to 11 hours each gave maximum errors of 2.4 per cent, minimum of 0.16 per cent.



The Tracing Point of the Pencil Records the Amount of Steam Consumed.

A NEW STEAM-METER.

Extensometer Methods and Bridges

Strains in bridge members, particularly those of long-span structures, have been the subject of so much controversy that it is reassuring to learn the uncertainty will be greatly reduced by the development and application of the delicate extenso-meter methods of measurement which the Bureau of Standards is employing very successfully under the direction of Mr. James E. Howard, its engineer-physicist. Mathematical analysis affords a sure mean of deducing stresses from definite assumptions, but in making assumption there are many chances of error, so that theoretical stresses and the resulting theoretical strains are by no means accurate, in a practical sense, and a check on them is highly desirable. If panel-point connections were actually rigid, for instance, the secondary stresses in some structures would be enormous, but these connections yield more or less under stress, so that the structure "finds itself," to use a shipbuilder's term, and it is certain that the actual strains are far less than those indicated by a rigid application of theory. It is highly important, however, to know what load is actually being carried by the members and still more important to know if the connections at the panel points and elsewhere are not overstrained in some detail. It is just as serious, of course, for a connection to fail as for a member to yield, and the ability to ascertain strains in detail by Mr. Howard's method is one of its most valuable features. The method permits the condition of any structure as respects strains to be determined as readily as its condition in regard to corrosion, and it can be carried out so easily that it deserves the thoughtful consideration of municipalities and railroad companies having important bridges, and of engineers called upon to report upon the safety of steel buildings. The city of New York, for example, might well employ the method in determining the strains in its long-span bridges which have been the subject of so much controversy. These delicate extenso-meter methods cannot be employed successfully by everybody, however, for only a few observers seem able to produce harmonious results, but this is something familiar to everybody acquainted with the refinements by physical measurements, in the laboratory as well as in the field.—*Engineering Record.*

The Gas Bladder of Bony Fishes

Some microscopic preparations and a model illustrating the mechanism employed in the production of the oxygen used to inflate the gas bladder of bony fishes, were exhibited at the recent Conversazione of the Royal Society by Dr. W. N. F. Woodland.

Most fishes employ oxygen (usually also nitrogen and carbon dioxide) for the inflation of the gas bladder (incorrectly termed "air-" and "swim-bladder") when this is present. The presence of oxygen is associated with the power of producing relatively rapid variations of the quantity of gas in the bladder, a power required in deep water fishes which sink and rise and so experience considerable changes in external pressure. A special gland, the oxygen gland ("gas gland"), and an equally important and very remarkable supplementary apparatus, the *rete mirabile duplex*, are developed in the bladder wall for the special purpose of producing the oxygen. The reason why oxygen is the gas employed for the inflation and deflation of the bladder is because of its abundance in the blood stream and the facility with which it is dissociated from (the red blood corpuscles undergoing disintegration for the purpose) and re-associated with the hæmoglobin of the blood.

The Pressure of Light on Gases*

An Experimental Study for the Theory of Comets' Tails

By Peter Lebedew

The peculiar forms developed in the tails of comets in the neighborhood of perihelion led Kepler,[1] almost three hundred years ago, to the thought that the sun's rays exert pressure upon the matter vaporized in comet's heads and repel it from the sun.

Additional weight was later given to this idea by Fitzgerald,[2] when he sought to base such an effect of the rays on Maxwell's force of pressure. In order to be able to compute the magnitude of the forces occurring, Fitzgerald first proceeded on the assumption that the separate gaseous molecules are absolutely black spheres, and that these spheres behave in respect to the incident light-waves in the same manner as would black spheres of very much larger dimensions. In the case of very small spheres, the phenomena of diffraction become significant, as was proved by Schwarzschild,[3] who rigorously computed the pressure of light on small perfectly reflecting spheres. Debye[4] solved this problem in a general way for small bodies of any desired constitution, and thus it is possible to subject to an accurate quantitative treatment the investigations suggested by Arrhenius,[5] which deal with the pressure of light on cosmical dust. It is not permissible for us to apply to the material of comets' tails, which, from their spectroscopic behavior, we must consider as consisting of separate fluorescing gaseous molecules, the computations which are valid for small spheres, as I pointed out long ago,[6] and in view of my proof that the separate molecules must be treated as resonators with selective absorption. Experiments which I made[7] with acoustic waves permit the observation of the continuous effect of these waves on movable acoustic resonators as sharply defined phenomena; the computations[8] which I made for electromagnetic waves permit us to infer an analogous effect of light-rays on separate molecules of gas. Debye[9] treated thoroughly the light pressure on a schematic molecule (a vibrating bipolar body) which is exposed to the solar rays in the same way as the gaseous molecules of a comet's tail; he then computed the numerical values of the repulsive forces thus arising.

Although the computations thus made, and the analogy with the acoustic resonators, scarcely leave any doubt as to the correctness of the idea proposed by Kepler, nevertheless it seemed to me to be in the interests of a theory of comets' tails based upon physical experience to see if direct experiments in the laboratory would give an unimpeachable proof of the repulsive effect of light on gases. Inasmuch as we are unable to deal with single molecules in such experiments, we are compelled to investigate the effect of light on a mass of gas which is compounded from the separate effects of the individual molecules. The resulting effect can readily be computed in this case, as was indicated by Fitzgerald,[10] who proceeded on the simple assumption that those rays only would exert Maxwell's pressure which were absorbed by the gaseous mass, and which, therefore, behave with respect to the gaseous mass like a black body. Then, in case of a beam of parallel rays, the repulsive force p in the direction of the ray will be

$$p = \frac{aE}{V}$$

where a is the coefficient of absorption of the energy E incident per second of time, and V is the velocity of light.

I. *Method.*—If a beam of rays of white light passes through a selectively absorbing mass of gas, then the mechanical forces which are to be expected must reveal themselves by the fact that the gas thus penetrated begins to displace itself in the direction of the motion of the light. Inasmuch as the coefficients of absorption of gases are in general very small, the repulsive forces develop, even under the most favorable conditions of the experiment, hardly amount to the hundredth of the pressure which the same beam of rays would exert upon a solid black wall. In order to be able to observe these small forces, the experiment had to be so arranged that the gas could freely move in the direction of the beam and act upon a sensitive valve which could not be directly affected by the beam of rays. Fig. 1 represents the apparatus constructed for this purpose: the gas is placed in a parallelopipedal cavity G, having windows, F_1 and F_2, of fluorite, and is so traversed by the bundle of rays L_1 L_2 that no rays fall upon the walls. If the beam of rays L_1 L_2 exerts a force of translation upon the mass of gas, then there must develop at the windows, F_1 F_2, differences of pressure in the gas which may become equalized by the dark space at the sides. This space at the sides is (almost) closed by an easily movable valve P; the valve P being hung on one arm of a torsion balance, the difference of pressure thus arising can be measured by the displacement of the valve P. After we have measured the diameter of the valve P, the directive force of the quartz-fiber Q, the length of the lever-arm of the torsion balance T, and the distance of the scale from the mirror of the reading telescope, we may readily compute in absolute measure the difference of pressure which corresponds to the deviation of the pressure apparatus by one scale-division. In this apparatus one scale-division $= 1.4 \times 10^{-6}$ dyne per square centimeter. A pencil of a Nernst lamp N (Fig. 2) served as a source of light: its rays were thrown on a rectangular diaphragm D, 2×3 millimeters, by the concave mirror S; then fell upon an inclined plane mirror P_1, and were united in a real image of the diaphragm by the concave mirror S_1 in the gaseous space G (Fig. 1) of the above-described pressure apparatus. The plane mirror P_1 can be replaced by P_2 without jar, by a pneumatic attachment, and the rays are sent by S_2 through the gaseous space of the pressure apparatus, in the opposite direction. Thus the change in direction of the rays doubles the deflection of the pressure apparatus due to the pressure of light on the gas, while the direct effects, which are due to the radiation of the warmed gas on the valve of the pressure apparatus, as a result of the unavoidably small differences of symmetry in the apparatus (which are independent of the direction of the effective rays) disappear.

The coefficient of absorption a of the gas to be investigated was determined by the aid of two thermo-elements T_1 and T_2, which were attached close to the fluorite windows; the ratios of their electromotive forces were determined by the galvanometer when the space for gas was filled, first with air, and then with the gas under investigation, and thus the coefficient of absorption was derived in a simple manner.

The energy of the beam was measured with a calorimeter by allowing the rays to fall for five minutes upon a block of copper K (Fig. 3) previously given a black coating of platinum on its front surface, and having a known water-equivalent; the rise in its temperature was then measured. I cannot here go into the details of this very difficult experiment, but refer to its more extended description in a paper to appear in the *Annalen der Physik*. I will here only briefly mention that obstacles of two kinds hinder the quantitative experimental testing of the relation proposed by Fitzgerald:

(*a*) The beam of rays can exert an appreciable translatory effect only upon gases which absorb selectively and which, therefore, are warmed by the radiation; change in their density gives rise to convection currents, and thereby can displace the valve of the pressure apparatus. These disturbing effects of the warming can be determined, however, by exhaustive investigations, and are not injurious when the apparatus is correctly set up. As these disturbing forces are decidedly smaller in mixtures of hydrogen than in pure gases, the definitive experiments were made solely with hydrogen mixtures.

(*b*) The simple relationships which Fitzgerald gave for a parallel beam cannot be realized experimentally, since in this case the energy of the beam cannot be made large enough. In a convergent beam the gaseous mass is not penetrated uniformly, differences of pressure arise in its interior, and the accurate computation of the effect of these differences of pressure on the valve apparatus cannot be made; we are, there-

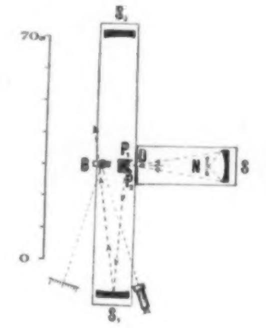


Fig. 2.

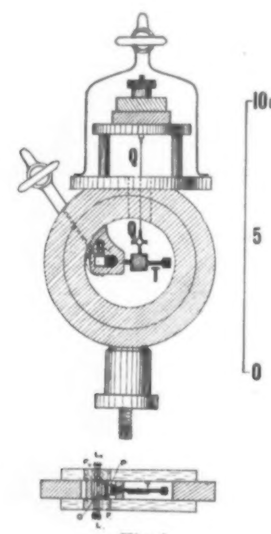


Fig 1.

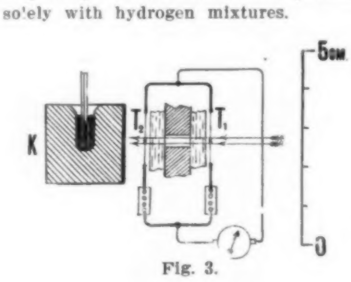


Fig. 3.

N		B	a	To	Pm	Pc	Pm : P
3	0.5 Methane—0.65* $H2$	0.65	0.0065	0.48	0.91	0.76	1.20
6	" " " "	0.60	0.0057	0.46	0.84	0.66	1.27
20	" " " "	0.70	0.0071	0.55	0.98	0.98	1.00
1	0.5 Propane—0.5 $H2$	2.05	0.0200	0.42	2.86	2.10	1.36
2	" " " "	1.75	0.0175	0.43	2.45	1.89	1.30
11	0.5 Butane—0.5 $H2$	2.10	0.0179	0.48	2.95	2.15	1.37
12	" " " "	2.00	0.0172	0.48	2.80	2.06	1.35
13	" " " "	3.10	0.0189	0.64	4.34	3.03	1.42
15	0.1 Butane—0.9 $H2$	0.55	0.0063	0.55	0.77	0.87	0.88
17	" " " "	0.70	0.0072	0.54	0.98	0.97	1.01
19	" " " "	9.65	0.0067	0.55	0.91	0.93	0.98
4	0.5 Aethylene—0.5 $H2$	0.60	0.0068	0.43	0.84	0.73	1.14
9	" " " "	0.75	0.0075	0.50	1.05	0.94	1.12
16	" " " "	0.80	0.0075	0.55	1.12	1.04	1.08
5	0.5 Acetylene—0.5 $H2$	0.85	0.0080	0.50	1.19	1.00	1.19
10	" " " "	0.85	0.0068	0.49	1.19	0.83	1.43
18	" " " "	0.70	0.0063	0.53	0.98	0.77	1.27
7	0.5 Carbonic Acid—0.5 $H2$	0.55	0.0055	0.50	0.77	0.69	1.11
8	" " " " "	0.55	0.0061	0.48	0.77	0.73	1.05
14	" " " " "	0.70	0.0072	0.51	0.98	0.92	1.06

* Reprinted from *The Astrophysical Journal*.

[1] J. Kepler, *De Cometis*. Augustae Vindelicorum 1619 Opera Omnia. Ed., Dr. Ch. Frisch. 7, 110, Frankfort, 1868.

[2] G. Fitzgerald, *Proc. Roy. Dublin Soc.*, 3, 344, 1883.

[3] K. Schwarzschild, *Sitzberichte der Münchener Akademie der Wissenschaften, Math. Klass.*, 31, 293, 1901.

[4] P. Debye, *Annalen der Physik* (4), 30, 57, 1909.

[5] S. Arrhenius, *Physikalische Zeitschrift*, 2, 81-97, 1901. See also *Lehrbuch der kosmischen Physik*, and *Das Werden der Welten*, Leipzig, 1908.

[6] P. Lebedew, *Wied. Ann.*, 44, 292, 1892.

[7] *Ibid.*, 62, 168, 1897.

[8] *Op. cit.*, p. 170.

[9] *Op. cit.*, p. 97.

[10] *Op. cit.*, p. 345.

fore, limited to estimates of the disturbing effects, and thus the computation of the absolute values of the forces of pressure to be measured from a and E are rendered decidedly more difficult and uncertain.

The result is that the relationships given by Fitzgerald can be tested quantitatively only to within about ± 30 per cent. It seemed to me necessary that I should content myself with this precision because the question as to the existence of the translatory effect of light on gases could be definitely decided, and because, on the other hand, the attainment of a greater precision was hindered by very great experimental difficulties.

II. *Results.*—The results of the definitive measurements are summarized in the foregoing table, in which N denotes the current number of the observation, B the measured deflection in scale-divisions of the pressure apparatus, a the measured coefficients of absorption, and T_0 the measured rise in temperature of the calorimeter in five minutes, by which the incident energy E of the beam is measured. The column P_m contains the absolute amounts of the directly measured pressures of the light on the gas, in millionths of a dyne per square centimeter, as determined from the measured deflections B of the pressure apparatus, from its linear measurements, and from the torsion of the quartz-fiber.

In column P_c are given the pressures, also in millionths of a dyne per square centimeter, computed according to Fitzgerald from a and E. The ratio P_m: P_c should be constant and differ only slightly from unity. The table includes twenty series of observations made with four different Nernst pencils as sources of light. This explains the different values of intensity of the ratio T_0 and of the absorption coefficients a for the same mixtures of gases.

The table shows that for each mixture of gases, the series of observations agree on the average within 10 per cent, corresponding to the possible errors of observation of the separate measures. For different mixtures of gases, in which the coefficients of absorption vary as 1:3 (methane and butane), and the density as 1:4 (butane), and the ratios P_m:P_c exhibit differences which lie outside the errors of observation and indicate slight instrumental errors in the adjustment which could scarcely be overcome in such exceptionally difficult experiments.

The results obtained may be summarized in the following manner:

1. The existence of the translatory force exerted by light upon gases is experimentally established.
2. These forces are directly proportional to the quantity of energy incident and to the absorption coefficients of the masses of gas.
3. The relationship proposed by Fitzgerald is to be regarded as quantitatively proved within the limit of errors possible in these experiments and computations.

These experiments refer to masses of gas under atmospheric pressure and the numerical values found cannot be directly applied to the excessively rare gases of comets' tails. They give, however, an experimental basis for the further exhaustive development of the physical theories of comets' tails propounded by Kepler.

Testing a Planimeter for Accuracy

A Misunderstood Instrument

By W. L. Durand

The planimeter is one of the most widely used of the measurement instruments employed by engineers, yet few understand the principles on which the planimeter is based or the methods employed to determine if a particular instrument in use is giving correct results.

The following are three tests that should be applied to all planimeters before complete reliance is placed on the readings they give:

Test for uniformity in the record-wheel readings.

Test for accuracy in the length of the tracing arm.

Test for parallelism of the recording-wheel axis.

To test for uniformity in the record-wheel readings a small check rule, as shown in Fig. 1, should be made of a thin strip of some metal such as brass. The rule is pivoted at O and the point of the planimeter is placed at one of the points on the rule, as shown in Fig. 2, and an area traced. Ten readings should be taken in this way, and then the tracings should be repeated in a negative direction, which should give the same readings as those in the positive direction. If the difference between the maximum and minimum result does not exceed 2 to 2.5 units of the vernier the planimeter may be considered to be correct in this respect. The errors are most apparent when the circle traced nearly coincides for some distance with the zero or base circle.

The zero circle is a circle around the pole point of the planimeter as its center and made by the tracing point so that the graduated wheel is continually travel-

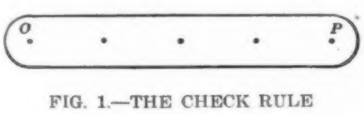


FIG. 1.—THE CHECK RULE

ing in the direction of its axis and consequently will not revolve. To find the zero circle, first a circle larger than the zero circle and then one smaller are drawn. The reading given by the planimeter for the larger circle is the area of the strip between the zero circle and the outer circle, while the area recorded for the small circle is the area between that circle and the zero circle. The area of the zero circle is equal to the true area of the small circle plus the strip between the small circle and the zero circle or to the true area of the large circle less the strip between the large circle and the zero circle. Hence, the area of the zero circle is equal to the true area of the small circle plus the recorded area of the small circle or to the true area of the larger circle less the recorded area of the large circle.

To obtain the best readings with any planimeter the zero circle should always be found and the area to be measured placed so that the circumference of zero circle runs through it, and the point of origin should be chosen on the zero circle so that a slight failure in returning to the origin will not be recorded by the wheel.

To test for the accuracy of the length of the tracing arm, trace by means of the check rule several circles of known areas a number of times, as shown in Fig. 3. Compare the mean of the results with the known area. If the results are too small by $\frac{1}{n}$th of the area the length of the tracing arm must be shortened $\frac{1}{n}$th of its length and *vice versa.*

To test for parallelism of the record-wheel axis use

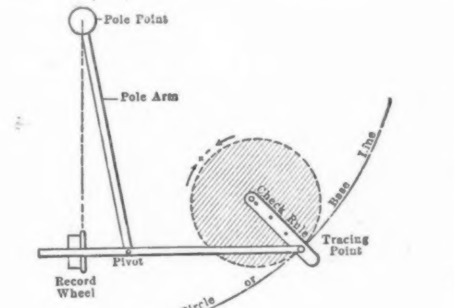


FIG. 2.—TEST FOR UNIFORMITY IN RECORD-WHEEL READINGS

the check rule, as shown in Fig. 4, and make a series of tracings of a circle outside the zero circle and another series of a circle inside the zero circle, keeping the circles as far from the zero-circle circumference as possible. If the readings outside and inside are equal the axis is parallel, but if the area recorded outside is the larger the end of the axis nearest to the tracing point must be moved toward the outside and *vice versa.*—*Power and the Engineer.*

Some Properties of Metals

A recent lecture by Dr. G. T. Beilby, F. R. S., puts in a very neat and picturesque way the changes in the properties of many metals due to cold working, and the subsequent softening effect of re-heating. These phenomena have in general probably been known since the days of Tubal Cain, but it is only within recent years that any adequate grasp of the phenomena has been obtained, and even now the knowledge of

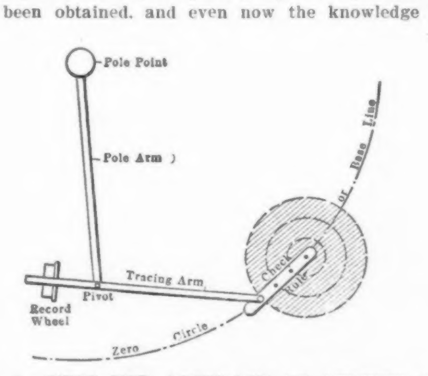


FIG. 3.—TEST FOR ACCURACY OF LENGTH OF TRACING ARM

the subject is very imperfect. Recent investigations tend to show, somewhat contrary to common opinion, that the softest state of a ductile metal is really a crystalline one, while in the hard state produced by hammering, rolling or wire drawing, the metal exists, particularly at the surface affected, not in the form of crystals, but in an amorphous condition, almost vitreous, differing from the crystalline condition, to follow one of Dr. Beilby's happy analogies, much as clear sugar candy differs from the familiar crystals of granulated sugar.

Recent investigations, too, show that the hardening process is accompanied by something very like a surface liquefaction, from which the following solidification is so rapid that there is no chance for the formation of crystals. Even so apparently impossible a material as calcspar shows on polishing what is apparently the result of something very like surface liquefaction to the depth, say, of less than 0.0001 millimeter, and metals show the same effect much more strongly. The same smearing effect is believed to take place in the polishing of glass and perhaps is a general phenomenon rather than one confined to relatively few materials. At all events, it takes place strongly in the case of metals, the crystalline structure being replaced by a vitreous one in the process of drawing and rolling, which vitreous condition is removed by annealing. The molecules reassemble themselves into crystals for a considerable range of temperature below the solidifying point. In hard drawing wire such phenomena are

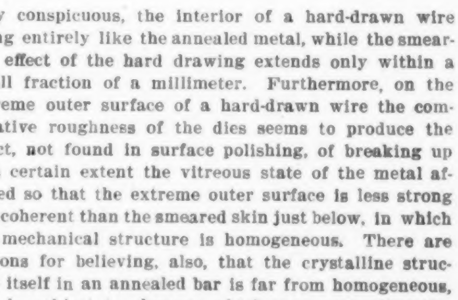


FIG. 4.—TEST FOR PARALLELISM

very conspicuous, the interior of a hard-drawn wire being entirely like the annealed metal, while the smearing effect of the hard drawing extends only within a small fraction of a millimeter. Furthermore, on the extreme outer surface of a hard-drawn wire the comparative roughness of the dies seems to produce the effect, not found in surface polishing, of breaking up to a certain extent the vitreous state of the metal affected so that the extreme outer surface is less strong and coherent than the smeared skin just below, in which the mechanical structure is homogeneous. There are reasons for believing, also, that the crystalline structure itself in an annealed bar is far from homogeneous, and is subject to changes which may even alter the dimensions of the bar itself in course of time, particularly in the case of some alloys.

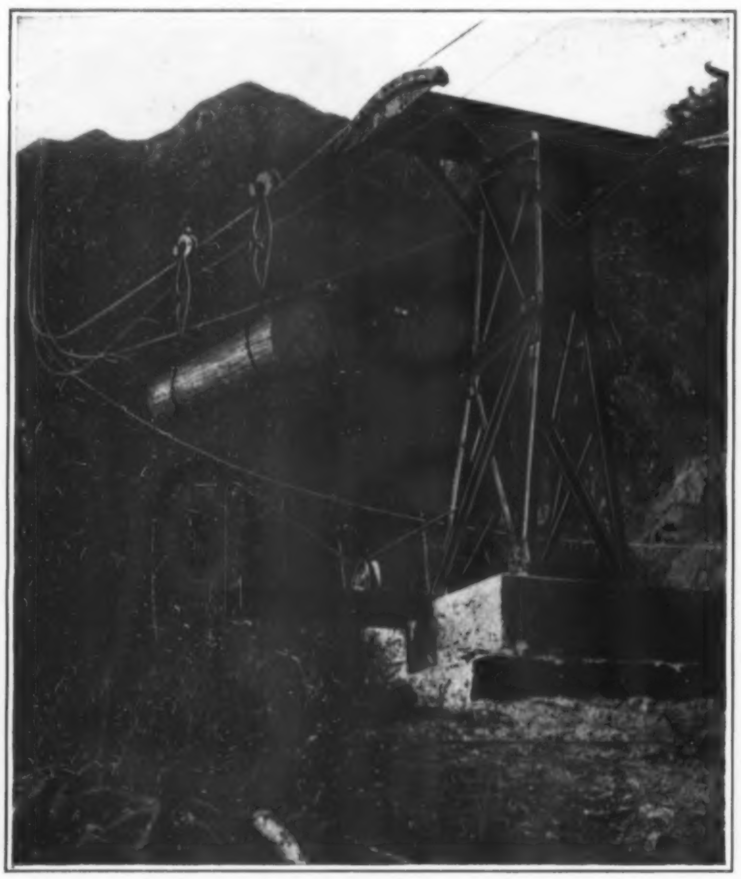
Research has gradually tended to break down the distinction between solid and supposedly rigid masses and fluids, and the later investigations show that the passage from one to the other form is sometimes astonishingly facile. To tell the truth, much less is known about the actual physics of solids than popular belief would indicate, and the facts tellingly marshalled in the lecture here considered are but a few of those which the physicist and the metallurgist must co-ordinate in the attempt to grasp the real meaning of the molecular structure of solids.—*Engineering Record.*

A Wire Ropeway for German East Africa

Transporting Lumber in a Jungle

By Frederick C. Coleman

Apart from the soil suitable for plantations, German East Africa possesses extensive forests, which, in the lowlands consist chiefly of mangroves. At a higher level in the Usambaras many cedars are found, which are exceptionally valuable on account of their providing good wood for pencils, the more so as the American cedar hitherto used shows a continual decline both in quality and quantity. The value of these forests at a height of 6,600 feet on the plateau of West Usambara will at once explain the efforts to turn them to account. These efforts were, however, met by very considerable difficulties, caused to a great extent by the precipitous formation of the mountains, which rise almost perpendicularly from the Penganis plain to a height of nearly 5,000 feet. There was no chance of overcoming difficulties of this kind with a surface line, and the plantation company, who had acquired a tor, driven in the usual way by a belt. As soon as the revolutions of the counter shaft begin to increase in number, owing to a reduced strain on the line, the throttle slide closes correspondingly and so checks the movement of the pump, and the latter then acts on the shaft as a strong brake. The track has a gradual rise from the loading station of about 295 feet, reaching the most elevated point of 5,220 feet above sea level, which is 4,995 feet above the loading station, some ¾-mile from New Hornow. To obtain a favorable profile a cutting was made when crossing the edge of the plateau, and in order to protect the foundations of the supports from the heavy tropical rains, the bottom of the cutting was laid on the slant and provided with side flood canals, further inclined canals also being provided before the supports. The inclination of the bottom of the cutting is adjusted to the an uncoupling point, which, as is usual with "Bleichert" constructions, are fitted with rails to give the necessary support to the running rollers on the carriages. The section below angle station I is extremely interesting as it is the steepest track in the world for continuous traffic, the gradient being no less than 41 degrees = 1: 1.15 or 86.93 per cent. The line now proceeds to angle station II with two spans of about 985 feet each, in one case carried by a lofty support of about 100 feet in height. In front of this station, room was also found for a support for the carrying ropes, which carries specially shaped carrying shoes about 4 feet in length. Easily renewable cast steel linings are also bolted on to these cast iron shoes, and a guard extends over the carrying rope in the center of the shoe, so that it cannot spring out of the saddle. In this way the carrying ropes have been



TOWER WITH CURVED SADDLES FOR CARRYING THE CABLES.

VIEW OF THE LINE WITH ANGLE STATIONS I. AND II. IN THE BACKGROUND.

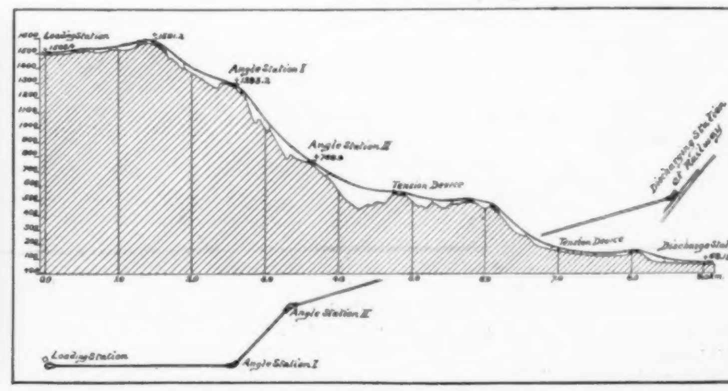
A WIRE ROPEWAY FOR GERMAN EAST AFRICA

concession to exploit these forests, decided upon a wire ropeway extending from the saw-mills on the plain to the station Mkumbara, a distance of some 5½ miles as the crow flies. The wire ropeway, as now completed, commences at the saw-mills, New Hornow, where the loading station is situated, and in which the drive and the brake regulator are also installed.

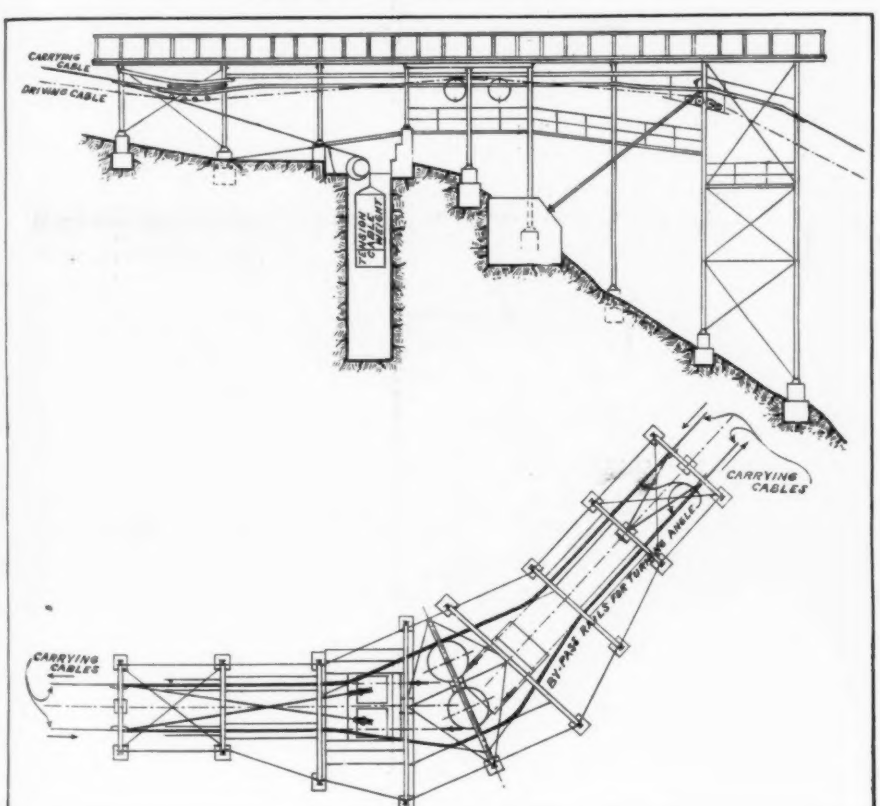
To maintain control over the line a 50-horse-power electric motor has been provided, capable of developing a high number of revolutions, and working by belting on to the driving shaft of the ropeway. Apart from the driving conical wheel, two large hand-brakes, one of which is provided for security with timber lined band and a sheave of about 6½ feet diameter, are fitted on to this shaft. When stopping the line, both of these brakes, which together can neutralize 100 horse-power, are tightened, although during work they are disengaged, as the regulation of the traveling speed is effected by a "brake regulator," and so rendered independent of human care and attention. The regulator in use is a hydraulic one supplied by the firm of J. Schrieder, Säckingen. It is driven by a belt from the counter shaft, and consists chiefly of a rotary pump and a balanced throttle slide. The former sucks the water from a reservoir in the foundation box of the apparatus, and forces it back through the passages of the governing valve into the box. The governing valve is actuated by a centrifugal regulaprofile of the track and has, therefore, on the declivity a fall of 1:2. The formation of the ground necessitated two angle joints to avoid spans up to about 6,600 feet. The line first leaves the plateau as a straight track and finds support on the side of a cone shaped mountain standing alone in front of the main range, at which point one of the angle stations has been arranged. Extensive blasting work was necessary to gain room for the profile of the ropeway and the angle station I, as the strata of the crumbly and weatherbeaten rock were found to run in two directions. Landslips were frequent, causing considerable delay to the completion of the line. The difficulty was, however, finally overcome by putting up a strong wall, facing and filling up the crevices with concrete. The carrying ropes for the first section of the line are tightened in the angle station I with a weight of 16 tons for the loaded rope and 13 tons for the unloaded rope, the tension weights consisting of iron frames filled with concrete cubes. The ropes for the second section are anchored in the same station. The traction rope of the first section passes on to the next following section and is guided in the station by means of deflection and guide sheaves. The station has not been arranged for automatic working as this was not considered necessary, labor for the transference of the carriers being both cheap and plentiful. Each rope is, therefore, provided with a coupling and drawn down to a far greater extent than would have been possible without protection, and the line can adapt itself better to changes in the formation of the ground. On these sections the traction rope must be guided as far as possible from the carrying ropes, to avoid its being, under sudden change of high tension, lifted enough to catch on the shoes of the supports. Owing to these considerations the shape of the supports differs very considerably from the usual designs. Extensive blasting operations and expensive foundation work were also necessary for angle station II, in order to provide room and support for the plant. The carrying ropes for the second section are tightened here, and in order to provide room for the tension weights a pit was blasted out of the rock. The traction rope from New Hornow terminates in this station, although it is connected with the rope on the third section to Kkumbara, so that a constrained movement between the two traction rope lengths can be maintained, hand braking not being considered reliable enough for the journey down to the valley. It was, therefore, advisable for the brake regulator in New Hornow to also act on the last section of the traction rope. On this last section, with its comparatively slight fall in comparison with the upper sections, there was also the danger that a stoppage would occur if the up-traffic were large and the downline insufficiently occupied. In order to effect the

necessary connection the traction rope of the two upper sections is guided round a sheave on the return shaft of the lower traction rope length. The traction rope of the upper section then goes over a return sheave fitted in a tension frame, tension being effected by tightening the tension-car under the action of weights. The profile from angle stations I and II towards the valley is one of remarkable boldness. Below the station is a deep valley which must be crossed with a span of over 2,950 feet, and a fall of some 660 feet in this distance. At the opposite side of the valley a double tension appliance for the third section has been erected, whence the line proceeds downward towards the level country, twice touching spurs of the Usambara mountains and ending at Nkumbara. The cuttings at the upper point occasioned exceptional difficulties. Towards the south the rock is formed of layers at 10:15 degrees, with fissures towards the west at about 45 degrees. The consequence was that frequent land-slips took place, which, after the first heavy rainy season, loosened large masses of rock and destroyed the supports which had been already erected. In this way the excavations necessarily increased to over 210,000 cubic feet, another example of the enormous difficulties which had to be coped with in the construction of this line. In the unloading station the ground is raised so that a platform has been formed, from which the logs can be very conveniently rolled into railway trucks. On account of the heavy changes in the fall and the long spans, the traction rope is subject to fluctuations in tension. It was, therefore, necessary to fit the traction rope tension weight for the third section in a tower in the unloading station, to give the weight sufficient play in the slide-path. The cars, which will carry logs up to about 46 feet in length and one ton in weight, consist of two carriages connected together by the traction rope. For the transport of cut timber, platform carriers are employed, which were furthermore necessary as it was desired to make use of them for passenger traffic. On account of the danger from white ants, all stations and supports are in steel construction, and the poles of the telephone of Mannesmann tubing, which, besides adding to the expense for sea and railway freights, considerably increased the cost of the plant. All these expenses have been kept well within the limits that could be expected for such a large undertaking. On the other hand, the cost of bringing the parts from the railway terminus Hombo up to the site of erection, the preliminary work, and the supplies of cement, water, etc., were very heavy. It often occurred that, for the transport of the material, special paths had to be cut, along which the objects were brought up separately by carriers. The erection was carried out by European engineers with the assistance of unskilled natives, who had to be brought long distances from the interior, as the Massai in the neighborhood will not work. It will, therefore, be easily understood that the extra expenses exceeded the actual cost of the deliveries many times over, and it will not appear incredible that the cost of the erection has been estimated at anywhere between $200,000 to $375,000. Today the line is in full work and has carried, since July, 1910, more than 35,000 cubic feet of cedar wood.

A CUTTING AT THE EDGE OF THE PLATFORM, WHICH SHOW THE REMARKABLE WORK DONE TO INSTAL THE TRANSPORTATING PLANT.



PROFILE OF THE WIRE CABLEWAY FOR BRINGING TIMBER FROM THE MOUNTAIN TO THE VALLEY.



DETAILS OF AN ANGLE STATION, SHOWING WEIGHTS FOR PRODUCING THE PROPER TENSION IN THE CABLES.

TENSION TOWER IN WHICH HEAVY WEIGHTS TAKE UP THE CABLE SLACK.

A WIRE ROPEWAY FOR GERMAN EAST AFRICA

A Thirty-Million Dollar Electric Project

WHAT is without doubt the largest suburban electric traction project in Europe is the one which is under way in France, concerning the change-over of a large part of the suburban lines in the region of Paris. This extensive piece of work is estimated at $30,000,000. We have already referred to the general features of the project, but are now able to give some further details as to the manner of carrying it out. Recently the plans for the work which were drawn up by the railroad engineers, were presented before a commission including the officials of the West State lines (the ones to be changed over), and other persons interested in the matter, and the plans were unanimously approved. It is now desired to begin as soon as possible, owing to the great congestion of traffic upon the west suburban lines. Electric trains will be run upon the 160 miles of the suburban network, taking in the region as far as Versailles. It is likely that the problem of suburban traffic will be very well solved by using the zone system, counting three zones starting from town. Each zone has separate trains which do not stop in the inner zones, thus securing rapid transit. Trains will follow in quick succession, especially for the portions near town, and they will be made up somewhat like the city subway trains, except that a much longer type of car will be used, holding 200 persons, seated and standing. The cars will be 72 feet long against 45 feet for the subway cars, and as before, the motor cars will carry passengers, using also a number of passenger cars of the same general build to make up the train, with a motor car at the front and the rear. The St. Lazare depot is the centering point for these lines within the city, and it will need to be remodelled to accommodate the electric trains. Passengers on the city subway can make a quick transfer to the suburban trains in this way, as the railroad depot is already one of the centering points of the subway, so that the whole plan will give most excellent facilities for the suburban traffic.

Practical Aspects of Printing Telegraphy—I*

An Inventor on the Difficulties to be Encountered and the Way to Overcome Them

By Donald Murray, M.A.

In a paper read before the Institution in 1905,† under the title of "Setting Type by Telegraph," an outline was given for the first time of the theoretical aspects of printing telegraphy. The author has always had in view the preparation of a second paper dealing with printing telegraphy from a practical point of view, especially in regard to the obstacles that stand, or formerly stood, in the way of the general introduction of printing telegraphs. The subject does not appear to have been treated in any publication, and as it is probable that these obstacles will, in time, acquire historic interest for telegraph engineers, it seems desirable to have them put carefully and fully on record. During the past ten years the author has had unique experience of these difficulties in New York, Boston, London, Birmingham, Manchester, Edinburgh, Berlin, Hamburg, Vienna, Stockholm, Gothenburg, St. Petersburg and Moscow, and the following paper embodies the results of that experience.

SUMMARY.

The paper is divided into three parts as follows: Part I., dealing generally with the field for printing telegraphy; Part II., dealing with the practical difficulties in the way of printing telegraphy; Part III., describing some printing telegraph apparatus designed to overcome these difficulties.

Part I. discusses the field for printing telegraphy, and it is shown that there is little scope at present for printing telegraphs in wireless work, in railway telegraph traffic, or on long ocean cables. Their use is chiefly in connection with land telegraph lines between centers of population, and it is shown that printing telegraphs will, in the future, perform a very important service in assisting the co-operation between telegraph and telephone. It is admitted that for transmission of intelligence over short distances the telephone stands unrivalled; but it is contended that for the transmission of intelligence over considerable distances the most efficient arrangement is a combination of the telephone and telegraph, the telephone acting as the collector and distributor for long telegraph lines. The reason is that the cost of long telephone lines is very great, while the labor cost of a telephone conversation is extremely small and the time saving is great. With the telegraph, on the other hand, the cost of the line is less than one-quarter of the cost of a telephone line; but the telegraph labor cost is very heavy and there is much loss of time. By co-operation between the telegraph and telephone the advantage of the cheap telegraph line is combined with the advantage of the low labor cost and time saving of the telephone. It is therefore contended that economic necessity will in future lead to a great increase in telephone-telegrams, or, as the British Postoffice already calls them, "phonograms." Printing telegraphs will form essential links in the telephone-telegraph network, because printing telegraphs are the only means by which the carrying capacity of telegraph lines can be greatly increased and the labor cost at the same time decreased.

Part II. is a long and detailed account of the difficulties that have been encountered in connection with the development and practical application of printing telegraphs. With the idea of forming an historical record of these difficulties, they have been fully and minutely described. It is pointed out in the first place that the saving of labor by the use of printing telegraphs cannot in the nature of things be very great; but that there is reasonable ground for expecting to save from 25 to 50 per cent in labor compared with the Morse key and sounder. The obstacles encountered in dealing with both commercial and press messages are discussed.

The difficulties in the way of making a copy for record of telegrams delivered are explained, and it is pointed out that wet-press copying is the only practical method of retaining copies of telegraph messages when printing telegraphs are used. The necessity for keeping copies of telegrams at all is not quite obvious.

When page-printing telegraphs are used a change is necessary in the telegraph forms used by various administrations. There are two kinds of telegraph messages, those sent from city A to be delivered in city B, and those sent from city A to be retransmitted in city B to city C. In city B nearly all telegraph administrations use two different kinds of telegraph forms to distinguish these two kinds of messages. For a page-printing telegraph only one form for both kinds of messages is possible.

Numbering telegraph messages presented some difficulties in England when the Murray automatic printing telegraph system was introduced.

Counting the number of words in telegrams is a serious burden. There are so many Siamese twin words that are neither one nor two, that counting words is difficult, and the necessity for careful checking and counting considerably diminishes the number of telegrams that it is possible to transmit per hour. It also increases the labor cost. If it were possible to charge for telegrams in some way by time as in the case of the telephone, instead of by words, a lot of delay and labor would be saved.

Errors in telegrams, due to the telegraph line, to the telegraph machinery, and to the human operator, impose very serious limitations on the time and labor saving possible with printing telegraphs.

The variety of telegraph messages and the irregularity in the flow of telegraph traffic also greatly reduce the possible time and labor saving.

Traffic arrangements and hours of duty of operators are necessarily of a very complicated character in the case of large telegraph administrations, and the introduction of printing telegraphs leads to considerable variation of these arrangements. It is most difficult to introduce changes in the daily routine of large numbers of human beings. Of course, in the case of France, Germany, and other countries on the Continent of Europe, where the Hughes has been largely employed for more than a quarter of a century, such difficulties have long since adjusted themselves. It is in the Morse key and sounder countries that the introduction of printing telegraphs necessitates some changes of routine.

International telegraph traffic presents special difficulties because of the division of authority and difference in habits and ideas and customs and differences in language.

Alphabetical troubles are not the least that printing telegraph inventors have to encounter. Each country requires some variation in the telegraphic alphabet, and it appears to be a physical impossibility to devise a printing telegraph that will suit all languages. A curious illustration of this alphabetical difficulty is the confusion that exists in Great Britain through the use of the oblique stroke both for money and fractions. 3/8 may be read as 3s. 8d. or as ⅜. This confusion has led to monetary loss.

Code and cipher messages are the despair of telegraph administrations, but on the whole a good printing telegraph can handle such messages with less risk of error than the Morse key and sounder, and at least as expeditiously if proper methods are used. The essential condition is careful training of operators in working on typewriter keyboards without looking at the keys.

The use of envelopes and the addressing of telegrams present difficulties in the case of page-printing telegraphs. On the Continent of Europe envelopes are not used, and the telegrams have to be folded up in special ways varying with each administration. The printing of the messages must suit these methods of folding. This requirement is hard to fulfill in the case of a page-printing telegraph.

Finally, there are mechanical difficulties of construction. Printing telegraph machines belong to a theoretically bad group of mechanisms, in which the majority of the actions are striking instead of sliding or rolling, and it is only by close attention to details that success has been achieved.

Part III. gives a brief general description of the Murray automatic system and a more extended description of the new Murray multiplex system as an illustration of some methods by which it has been attempted to save time, line, and labor in telegraphy, and to overcome the difficulties enumerated in Part II.

PART I. INTRODUCTION.

For any distance exceeding a few miles, our sole physical means of transmitting intelligence at a speed greater than by letter post is the electric wave. There are only two possible methods of using the electric wave for signaling—namely, the guided wave along a wire (ordinary telegraph and telephone) and the unguided wave (light signals and "wireless"). Electric waves in the form of light have so many limitations that they are of no importance from the printing telegraph point of view, except as a local means of printing, and further reference to them in this paper is not required. As the longer waves used in wireless telegraphy have a much greater range on the surface of the earth, no doubt in time wireless printing telegraphy will receive more or less attention, but it will not be of much importance, in this generation at any rate, because there cannot be any saving of line or line maintenance when there is no line. Any saving of labor that might be effected by wireless printing telegraphy is of trifling importance, because the wireless operator has to be in attendance in any case, and the speed of signaling is low. It is in submarine telegraphy, where it is impossible to use the guided electric wave, that wireless telegraphy has its great field, and in nearly all cases of ship telegraphy the work can be dealt with easily by one operator. Also the Morse key is the quickest means of communication (excepting the telephone). Hence in most wireless work, printing telegraphy would save neither line, labor, nor time. There is nothing else that it can save. Under such circumstances the extra cost and complexity of printing telegraphs would not be justified. Possibly for rapid transmission of wireless messages between two fixed centers, printing telegraphs may come into use, but not in the immediate future. Wireless printing telegraphy therefore does not require consideration, and we may confine ourselves to the guided electric wave as used with the telephone and telegraph, including underground and submarine cables. Transmission of intelligence so far as the guided electric wave is concerned may be classified into short-distance and long-distance telephone traffic and short-distance and long-distance telegraph traffic. Further subdivisions of telegraph work, which overlap more or less, are land traffic, cable traffic, news work, commercial and other ordinary short telegrams, railway work, and the stock ticker and urban news service.

It is not necessary in this paper to touch on the local transmission of intelligence over distances more or less within city limits. For this purpose the telephone and stock ticker and telautograph have reached a high state of development and form a group by themselves. The difficulties they have had to face have been almost entirely mechanical. No serious obstacles have been presented by the nature of the traffic they have to deal with. Hence they will only concern us in so far as they serve as feeders to the general telegraph and telephone network between centers of population.

For railway work printing telegraphs have hardly been employed at all up to the present, and as the telephone is gradually displacing the telegraph for most railway work in America, and therefore no doubt in time in other countries also, printing telegraphy does not appear to have any extensive possibilities in conjunction with railways, and it therefore does not require special discussion at present. In time, printing telegraphy will probably play a considerable part in connection with ocean cables, but up to the present hardly anything has been done in this direction, because the conditions to be fulfilled are extremely complicated. In the first place, there cannot at present be any line saving, because ocean cables are already utilized up to their full capacity. It will be possible to effect a slight saving of time and some saving of labor, but the apparatus will necessarily be of a very delicate and intricate character. The expenditure will necessarily be heavy, and the saving will not be more than about £300 or £400 a year on each cable, at each end. The saving of time is more important on the Atlantic cables, and reliable apparatus that would print messages in Roman type direct from the cable signals would be attractive to the cable companies in places like New York, where the cables terminate in Wall Street, the business heart of the city. Meanwhile, the attention of printing telegraph inventors is absorbed by land line work, and printing telegraphs for ocean cables have to wait. The application of printing telegraphs to news work will be dealt with later on.

So far as the present position of printing telegraphs is concerned, the Hughes tape printer carries the bulk of the telegraph traffic on the Continent of Europe, and it has done so for nearly half a century, about 3,000 Hughes instruments being now in use. Most of the telegraph traffic between Great Britain and the Continent is also carried by the Hughes, but this machine is employed outside of Europe only to a very slight extent. During the past thirty years the

*Paper read before the Institute of Electrical Engineers.
†*Journal of the Institute of Electrical Engineers*, vol. 24, p. 555, 1905.

Baudot system, which may be described as a multiplied Hughes tape printer, has been developed and extended in France, until all the telegraph lines of any importance are equipped with it. During recent years it has also made considerable progress in Italy, Brazil, India and Russia. In Russia it is very extensively used, most of the leading towns in European Russia being connected by it. It has likewise secured some foothold in most other European countries, Paris being linked up by it to nearly all the capitals of Europe.

Great Britain has proceeded in very leisurely fashion, and so far has only coquetted with printing telegraphy, more or less prolonged flirtations having been carried on by the British Postoffice with the Hughes and Baudot, the Buckingham, the Murray automatic, the Siemens and Halske, and several other systems. The latest arrival, the Murray multiplex, may be described as the child of the British Postoffice, it having been developed with the assistance of that institution. The Murray automatic system has made most progress up to the present in Germany. It has also secured a foothold in Russia, Sweden, and Norway. It is in regular commercial use between Hamburg and Berlin, Berlin and Frankfort, Hamburg and Frankfort, Berlin and St. Petersburg, St. Petersburg and Omsk in Siberia (about 2,400 miles, with three repeating stations), Stockholm and Gothenburg, Kristiania and Bergen. A new installation with all the latest improvements is being established between London and Dublin. For various reasons, however, the use of the Murray automatic system is limited to long lines and underground cables, and there is consequently not a very wide field for it, especially in comparatively small countries like Great Britain. The Murray multiplex, on the other hand, is very well adapted for moderate distances, but it has not yet had time to come into extensive use. In the United States the Buckingham system was developed under the auspices of the Western Union Telegraph Company, and some sixty circuits are now equipped with the Buckingham system as improved by Barclay.

Printing telegraph inventors are still busy increasing the height of the printing telegraph scrap pile, as they have been doing for fifty years, especially in America, but the substantial results over the whole wide world are summarized in the foregoing paragraphs. These results are neither extensive nor brilliant, and it is an actual fact that less than £1,000,000 sterling would cover the value of all the printing telegraph machinery on the face of the earth to-day. This is the outcome of fifty years of constant labor by scores of inventors. We have only to compare this with the gigantic extension of telephone apparatus all over the world in only a few years to realize that there must be some hampering circumstances, some peculiar difficulties and obstacles in the way of printing telegraphy, when we compare its stunted growth with the enormous progress of the sister art of telephony. It is the intention in this paper to give a full and detailed account of these peculiar obstacles and difficulties, and of the exceedingly complicated conditions with which printing telegraph systems have to comply.

For this purpose it is necessary first to get a clear, general view of the practical processes employed in the transmission of intelligence by the telephone and by the telegraph. In doing so we have to bear in mind that in the transmission of intelligence there are four economies of fundamental importance, namely:

1. To save time.
2. To save labor.
3. To save line.
4. To save office equipment.

Everything turns on these four vital points. They are all more or less antagonistic economies. Time, for instance, can be saved by increasing labor cost or *vice versa*. Good management is a question of balancing these economies against one another so as to secure the maximum result. Investigation shows that it is far more important to save time, labor, and line than to save office equipment. Heavy expenditure on office equipment in the shape of printing telegraph machinery is therefore one of the inevitable developments of the future. As will be seen presently also, the necessity for co-operation between the telegraph and telephone will compel development in the same direction. That the relation of the telephone to the telegraph has an important bearing in regard to printing telegraphs will be seen from the following considerations: In the case of the telephone the sender and receiver of a message are put in direct communication, and there is no intermediate labor whatever. This result, however, is only obtained over anything more than moderate distances by heavy expenditure on telephone lines. Two expensive copper wires are needed for the telephone in place of one cheap iron wire for the telegraph. The telephone line expenditure, in fact, is so heavy for long distances that beyond about 1,000 miles the cost becomes almost prohibitive. The theoretical reasons for the great differences between telegraphic and telephonic methods were given in the paper on "Setting Type by Telegraph," already referred to* and it is only necessary here to deal with the practical aspects of the matter. In the case of the telephone there is no scope for machinery, so far as the actual transmission of the message is concerned, because there is no labor at all beyond speaking and listening. The cost of a telephone message over a short distance is therefore very small—2d. for about 200 words sent and 200 received in reply—and there is absolutely no delay or loss of time except in getting connected. Obviously the telephone saves enormously in time and labor, that is to say, in two out of the four vital elements of cost. It is this enormous economy that has led to the expenditure of such immense masses of capital in the extension of the telephone service all over the world. In the case of the telegraph the conditions are almost exactly opposite, and the telegraph at present is more or less crushed between the upper and nether millstones of the telephone and the letter post. It is only over long distances that the telegraph stands supreme, and it does so because of the very low cost of the telegraph line compared with the telephone line. The relative value of the telegraph increases and the relative value of the telephone decreases rapidly in proportion to the distance.

Let us take the case of a business man in London who wants to communicate with a man in Birmingham, a short distance of about 120 miles. If he telephones he gets direct communication in a few minutes and at no great cost. (There is, of course, often considerable delay in getting a trunk connection, but it is much less than the delay in getting a reply by telegram.) If he telegraphs he has first to dictate the telegram to a clerk, who writes it out and hands it to a message-boy, who takes it to the nearest telegraph office and hands it to a counter-clerk, who counts the number of words and collects payment. A messenger then takes it and puts it in a pneumatic tube, by which it goes to the London central telegraph office. Here a messenger takes it out of the tube and it goes to a table sorting clerk, then to a messenger, who again puts it in a pneumatic tube to one of the telegraph galleries (operating halls). Again in the gallery it goes through the hands of a sorting clerk, and then a distributor takes it to the circuit box, where it is dealt with by the traffic clerk of the circuit. An operator then telegraphs it over the line to Birmingham, where it is received by another telegraph operator. It is taken away by a collector to a delivery officer to be enveloped and addressed, Then finally a messenger takes it to the addressee. In the case of the messages passing from city A through city B to city C the human chain is still further extended, but taking the foregoing as a fair average journey for a telegram, we see that between the sender and receiver of the message there are no less than fifteen middlemen. In the case of long-distance messages this chain of middlemen may easily extend to twenty or thirty. Not only is there heavy labor cost, but also much time is lost in this elaborate process. The result is that not only does an average telegram take an hour or more to reach its destination, but the excessive labor employed in handling it makes it very costly. Instead of 2d. for about 400 words, a telegram costs 6d. for 12 words—that is to say, 1d. for 2 words instead of 1d. for 200, as in the case of the telephone.

The vital importance of printing telegraphs lies in the fact that they can greatly reduce the present waste of line and labor in telegraphy, and that they render it possible to foster the growing co-operation between the telegraph and the telephone. The telegraph and telephone are each strong where the other is weak. We can set out the points in tabular form thus:

	Telegraph.	Telephone.	T'graph-T'phone
Time	Wasteful	Extremely econom.	Fairly economical
Labor	Wasteful	Extremely econom.	Fairly economical
Line	Very econom	Very wasteful	Very economical
Office equipment ...	Cheap	Expensive	Expensive

If we utilize the telephone as the short-line feeder and distributor for the long-line telegraph we get the ideal co-operation shown in the last column of the table. The cost of office equipment will be increased, but this will be outweighed ten or twenty fold by the economies of line, labor and time.

If telegraph messages were charged for like telephone messages, by time instead of by the number of words, a lot of the labor cost would fall away. A merchant would then ring up the nearest telegraph office. He would be switched onto the required circuit, and he would dictate his message direct to a telegraph operator, who would type it on a rapid keyboard tape perforator. The perforated message would run through an automatic transmitter, and would be printed automatically direct from the line signals at the distant station, from which point it would be telephoned at once to the addressee. In this way the elaborate telegraph labor chain would be reduced from twelve or fifteen to about four, with corresponding reduction in the cost and saving of time. This may be an impossible ideal, but there is no reason why there should not be some approximation to it. Indeed, this telephone-telegram idea is already slowly emerging into everyday use. The British and other administrations now accept and deliver telegrams by telephone, and the British Postoffice has actually coined the special name of "phonograms" for such telephone-telegrams. As telegrams can already be sent to or from a telegraph office by telephone, it is only a question of time for several more links in the long telegraph labor chain to be cut out, and *messages will be sent by telephone direct to the particular telegraph circuit over which they are to be transmitted.* There will be no more difficulty about that than there is in handling trunk telephone calls. It will be noticed, however, that the success of such an arrangement is conditional upon the rapid handling and transmission of the messages. If a merchant wished to dictate a message over the telephone direct to a telegraph operator on a particular circuit, and if he had not only to await his turn, but also to dictate at the crawling manual speed of the Morse key and the operator writing at the other end of the telegraph line, the arrangement would never come into popular favor. The message should be recorded on perforated paper tape from dictation over the telephone at a speed of at least sixty words a minute, or it should be recorded at this speed or more on a typewriter at the circuit over which it is to be transmitted. Also the best the slow Morse key can do is to give two simultaneous transmissions in one direction on one telegraph wire. To handle "phonograms" under ideal conditions there should be a system giving either high automatic speed of transmission or at least four simultaneous transmissions in each direction on busy lines, and the speed of each transmission should be a steady average of at least forty words a minute.

Not only would quick handling and transmission of messages be necessary, but also quick reception and printing of the messages at the other end of the line ready for transmission by telephone. Printing telegraphs are a necessity for such methods of handling telegrams. Even in the case of the general public, who would continue to hand in their telegrams in the usual way at telegraph offices, much time and labor would be saved if the messages could be sent by telephone from the local telegraph office direct to the trunk telegraph line and recorded on a keyboard perforator in the form of perforated paper tape, ready for automatic transmission. The chief stumbling-block at present in the way of this arrangement is the practice of charging for telegrams according to the number of words. An incredible amount of time and labor is wasted in counting the number of words in telegrams. The telephone prospers without counting and recounting words. The telephone does not reckon "three-halfpence" as one word and "three hundred" as two words, to say nothing of other telegraphic word-counting absurdities. A rational system of charging for telegrams is badly needed, but it is difficult to imagine what plan could be substituted for the present clumsy but practical arrangement.

In addition to the telephone as a local collector and distributor of telegrams, there appears to be a field for the small step-by-step printing telegraphs generally known as stock tickers. The Siemens and Halske teletyper is a good example of this class of machine. From a technical point of view it is an admirable little instrument, and on the Continent of Europe it is being exploited commercially with considerable vigor and success. It is very largely in use in Germany, Berlin and several other leading German cities having ticker exchanges in connection with the head telegraph offices arranged somewhat on the lines of a telephone exchange. Any subscriber can send telegrams to the head telegraph office or receive them by means of the teletyper. By having one or two of these little instruments at each important circuit, and by having suitable switching arrangements in the exchange, subscribers could send in their messages direct to any required circuit or receive them direct from any circuit in the same way. The advantage of this arrangement would be that there would be a printed record of the message in the office of the sender and also in the head telegraph office, and it is probable that there would be less liability to mis-

* *Journal of the Institution of Electrical Engineers*, vol. 24, p. 555, 1905.

takes than in the case of the telephone. These little machines, however, are more expensive and complicated and slower than telephones, and in the nature of things can only come into very limited competition with the telephone. The same remarks apply to the telewriter. This will also, no doubt, prove useful in collecting and distributing telegrams locally, but it is the telephone that will do the bulk of the collection and distribution of messages sent over telegraph lines.

Meanwhile we have to see what steps we can take to reduce labor cost of telegrams under present conditions. The line cost also is important, but nothing like so important as in the case of the telephone, and, except in the case of very long lines, it is not so important as the labor cost. On the other hand, we have the letter post, by which we may send 5,000 or more words for one penny. The time of transmission is a good deal greater than in telegraphing over long distances, but there the advantage of the telegraph ends. Why spend sixpence on a telegram when you can telephone for twopence or send a letter for a penny or a postcard for a halfpenny? The answer is, that you cannot telephone for twopence except over short distances, and that letters take a long time to go long distances and telegrams do not. The telegram is the cheapest quick method of communication over considerable distances. The subject is very complicated, and there are many obstacles, but threepenny telegrams and quick service would lead to a wonderful growth of telegraph traffic. Threepenny telegrams and quick service depend on rational co-operation between the telegraph and telephone, upon the extension of the telephone to practically every office and home, and last, but not least, upon efficient printing telegraphs. It is a more or less instinctive appreciation of these facts that has led the British and other telegraph administrations to experiment so extensively during the past few years with various new printing telegraph systems. Much yet remains to be done, but it is practically certain that in the course of the next ten or fifteen years the British Postoffice alone, to say nothing of other administrations, will have to spend not less than a quarter of a million sterling on printing and other telegraph machinery in telegraph offices—that is to say, on "office equipment." There are, of course, many other relative advantages and disadvantages of the telephone, telegraph, and letter post, but it is not necessary to discuss them here, as they have no special bearing on printing telegraphs.

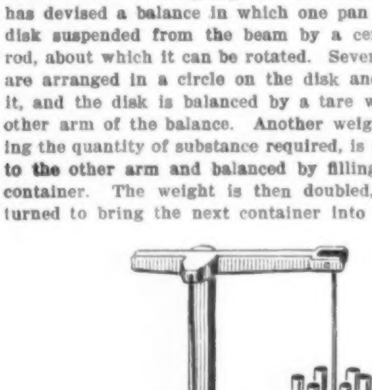
(To be continued.)

New Physical Apparatus*

Interesting Devices from European Laboratories

RAPID PRECISION BALANCE.

In commercial and industrial laboratories it is often necessary to make a series of weighings of equal quantities of material. For this purpose it is customary to employ a small nickel measure similar to those used by grocers, which is "tared" once for all, and is cleaned with a brush after each weighing. The weight of the measure, however, may be altered, by contact with the hand and other causes, in the course of the series of weighings, and some of the substance weighed may be retained by the brush. For precise determinations of weight, the tare of the container must be determined each time, immediately before it is filled. In order to shorten the time required to make a series of weighings in this manner, Dr. Gerber has devised a balance in which one pan consists of a disk suspended from the beam by a central vertical rod, about which it can be rotated. Several containers are arranged in a circle on the disk and attached to it, and the disk is balanced by a tare weight on the other arm of the balance. Another weight, representing the quantity of substance required, is then attached to the other arm and balanced by filling the nearest container. The weight is then doubled, the disk is turned to bring the next container into a convenient



RAPID PRECISION BALANCE

position and the balance is restored by filling this container. In this way all of the containers are filled, the weight being increased by a constant amount each time.

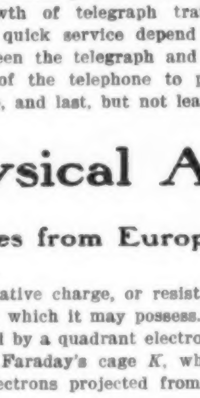
VELOCITY OF ROENTGEN RAYS.

In 1905 Marx completed an extensive series of measurements, made by a zero method, which appeared to prove that Roentgen rays are propagated with the velocity of light, that is, 300,000 kilometers, or 186,000 miles, per second. Although there was no inherent improbability in this result, many physicists were unwilling to accept it, because the method of measurement appeared involved and open to ambiguity.

According to the hypothesis of Wichert and Stokes, the Roentgen rays are caused by unharmonic or aperiodic disturbances in the ether, and are consequently propagated with the velocity of light. Bragg, on the contrary, regards the Roentgen rays as very rapid secondary cathode rays, composed of neutral pairs of oppositely electrified particles, analogous to binary stars.

Marx has recently repeated the measurements by an improved method. He still finds the velocity of Roentgen rays equal to that of light, within 3 per cent, which is the probability of error of the measurement. The accompanying diagram shows the apparatus and the principle of the method. The Roentgen rays are produced by a small vacuum tube *A*, at a variable distance from which is placed a second vacuum tube *B*, containing an aluminium plate *P*. Roentgen rays striking this plate will promote the loss of any negative charge, or resist the loss of any positive charge, which it may possess. The discharge can be measured by a quadrant electrometer connected with the little Faraday's cage *K*, which is arranged to catch the electrons projected from the aluminium plate *P*.

The tube *A* is traversed by an alternating current

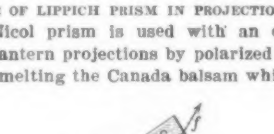


APPARATUS FOR MEASURING THE VELOCITY OF ROENTGEN RAYS

of high frequency, and therefore emits Roentgen rays, not continuously, but periodically at very short intervals. Similarly, the negative charge of the plate *P*, which is favorable to the detection of Roentgen rays, is not maintained continuously, but is produced periodically by a high frequency current. In order to cause a deflection of the electrometer the Roentgen rays must strike the plate *P* at the exact moment when it is negatively electrified. The two high frequency currents were generated by the same oscillator, and were consequently of the same period. The plate *P* was connected with the oscillator by a wire of variable length *D*, along which the electric waves travel, as is known, with the velocity of light. The Roentgen rays reached the plate by traveling the distance *AP* through the air. The position of the detector tube *B* and the length of the wire *D* were first adjusted to produce a maximum deflection of the electrometer. The distance between the vacuum tubes *A* and *B* was then altered by a measured amount and the wire *D* was lengthened or shortened until a maximum deflection of the electrometer was again produced. To obtain this result it was found necessary to increase or decrease the length of the wire by an amount equal to the increase or decrease in the length of the air path followed by the Roentgen rays. Hence the experiment shows that Roentgen rays travel with the velocity of light. This result is at variance with the theory of Bragg, and confirms that of Wiechert and Stokes.

USE OF LIPPICH PRISM IN PROJECTION.

When a Nicol prism is used with an electric arc for making lantern projections by polarized light there is danger of melting the Canada balsam which cements



LIPPICH PRISM

together the two parts of the prism. This danger is greater now than it was formerly, because the increased cost of objects made of calcspar leads to the employment of small prisms, which are exposed to a very concentrated beam of light.

A Nicol prism is made by bisecting a natural rhombohedron of calcspar along a plane inclined at a certain angle to the optic axis and interposing a thin stratum of Canada balsam between the two halves *A* and *B* (see illustration). A ray of unpolarized light, entering the film parallel to the axis at *a*, is divided within the doubly refracting crystal into two polarized rays, one of which, called the "ordinary" ray, is refracted to *d*, where it is totally reflected to the side of the prism at *e* and there absorbed by a coating of black pigment, while the other, called the "extraordinary" ray, passes straight through the compound prism along the line *a b c*. It is the suppressed "ordinary" ray that does the mischief, for its absorption by the black coating heats the prism. Moreover, in most cases it is not entirely absorbed, and therefore causes optical disturbances. It was for the latter reason that Lippich suggested polishing a portion of the side of the prism and attaching a triangular glass prism *C*. By this device the "ordinary" ray is conducted entirely out of the prism, along the line *e f*. As the production of heat by absorption is eliminated, together with the optical disturbance, Lippich's modification of the Nicol prism is especially well adapted for projection, and it has been used for that purpose with excellent results.

A NEW LINEAR BOLOMETER.

A bolometer is an instrument for measuring radiant heat by means of the increase of the electrical resistance of a conductor exposed to the radiation. This conductor, *w*, is inserted in one side of a Wheatstone

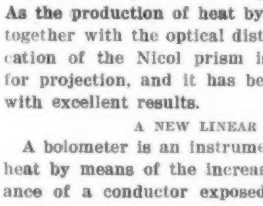


Fig. 1

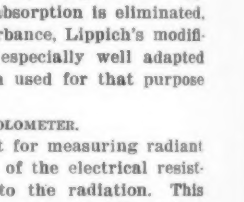


Fig. 2

bridge (Fig. 1), and the resistances of the other three sides *a b c* are so adjusted that no current flows through the diagonal containing the galvanometer *g*. The bolometer conductor *w* is then exposed to radiation, which raises its temperature, and, consequently, increases its resistance, so that the balance is destroyed and the galvanometer needle is deflected.

In practice it is desirable to arrange the apparatus according to the more complex scheme of Fig. 2, in which variations in the temperature of the air have less effect, and in which the conductors, 1, 2, 3 and 4 must be of the same material. The character of these conductors is of the utmost importance. They must have as large a surface as possible, small thermal capacity and high resistance, and yet must be able to carry strong currents.

Leimbach has recently constructed a linear bolometer of extraordinary sensitiveness, in which the conductors are platinum ribbons about ½ inch long, 1/1,000 inch wide and 1/100,000 inch thick. These ribbons were produced by stretching and flattening platinum wire thickly plated with silver (Wollaston wire) and then dissolving the silver in nitric acid.

*These brief notes are taken from our French and German contemporaries, *La Nature* and *Prometheus*.

Roman Portraits of the First Century, A. D.

Prof. William F. Petrie exhibited at the recent Conversazione of the Royal Society some Roman portraits of the first century A. D.

These portraits are painted with colored wax upon thin panels of cedar. On some a fresh coat of paraffine has been now added for security. They were placed over the faces of the mummies and bandaged down round the edge. They are from the same cemetery, at Hawara, Egypt, as those in the National Gallery, a site now exhausted by the British School of Archæology in Egypt.

Light and Life*

The Effect of Light on the Movement of the Lower Organisms

By S. O. Mast

By "lower organisms" we mean the simpler of the living beings, mostly microscopic forms. Of these there are hundreds of different kinds, many more than could be even named in the time at my disposal. I shall consequently confine what I have to say largely to one or two of these creatures.

Light has either directly or indirectly, a very profound effect on all living things, including the human being. Much has been written in the past years concerning the germicidal effect of light. It is known that the shorter rays, the blue, the violet and the ultraviolet, kill many of these germs (bacteria and some other lower organisms). However, there are many lower organisms that are somewhat more complicated than the bacteria, and while they may not be killed as readily as the germs mentioned, it is found that intense light, such as direct sunlight, almost invariably has an injurious effect on them. If the light is too intense, they cannot withstand its effect for any great length of time. It is assumed that the injury is due to a breaking down of the protoplasm, a photochemical change, a simplifying of the chemical substances within the living organism.

Light is, however, by no means always injurious. It may have a synthetic as well as an analytic effect on chemicals. Simple compounds, as for example, carbon dioxide and water, are united to form the carbohydrates and other compounds. This takes place only in the presence of light and the green substance, chlor-

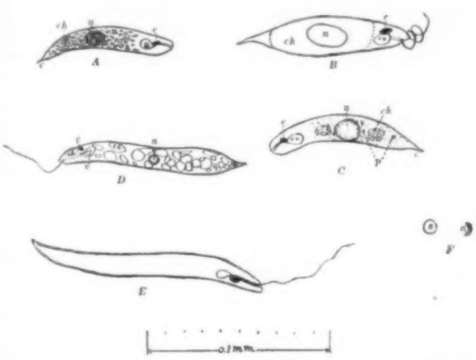


Fig. 1.—Euglena, showing general structure of different forms.

A. C, Euglena in crawling state; B, probably a form of E. viridis; D, E. E., deses; e. s., pigment-spot; c. v., contractile vacuole; c. h., green bodies containing chlorophyll, space in B limited by dotted lines well filled with small ones; n, nucleus; c, caudal spine; p, pigment granules which appear to be composed of same substance as pigment-spot—these were found in only a few specimens; F, pigment-spot highly magnified; s, surface view; a, view from anterior end. The convex surface is directed outward. mm. projected scale with the same magnification as the Euglenas. All outlines were made with camera from specimens killed in iodine. Contractile vacuoles and nuclei were sketched free hand from living specimens.

ophyl, that is found in leaves and other plant structures and in many of the lower organisms.

Most of us do not fully realize that, if it were not for this synthetic process, the building up of the simpler substances into more complex, which, as stated before, takes place only in the presence of light, no living being could long exist on this earth, for every organism, plant as well as animal, must have complex chemical compounds as its food material, and these are at present synthesized only in the presence of light and chlorophyll embodied in living matter. Green plants can manufacture their own food, but all other plants and nearly all animals are not able to do so. They are dependent directly or indirectly upon green plants for food. Let me illustrate. Floating in nearly all of the waters of the seas near the surface are innumerable microscopic, green plants of various kinds. Each one of these minute specks of living matter contains chlorophyll and is in reality a synthetic laboratory in which, in the presence of light, the complex food substances necessary for life are manufactured from chemical elements and simple compounds. The complex compounds thus formed are taken in by myriads of small animals which feed on the minute plants, and some of these compounds are passed through larger animals—minnows and small fishes, which devour the small animals, to still larger fishes and other creatures, which in turn find their way into the stomachs of the next size, and so on, until the largest are reached. Thus even those fishes which live entirely on other fishes, carnivorous creatures, are dependent upon minute green specks of living substance for the manufacture of essentials in their food supply, and the motive power in these factories is light.

If the light is too intense, it is, as already stated, injurious to most of the lower organisms. If it is too weak the synthesis of food substance is interrupted. It will readily be seen, then, that it is of the greatest importance for these organisms to be able to aggregate

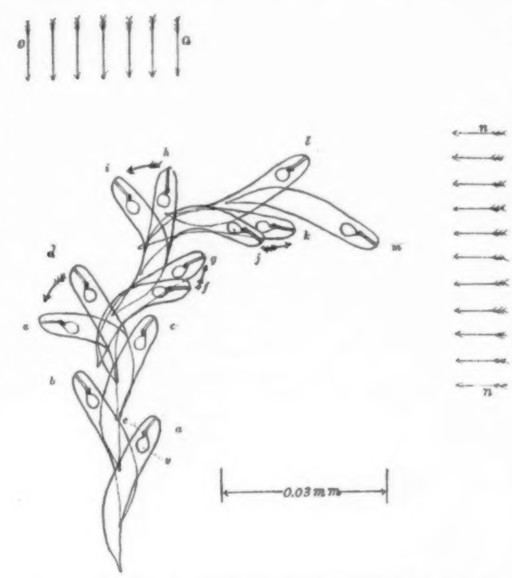


Fig. 2.—Euglena in crawling state showing details in process of orientation.

c., contractile vacuole; e., eye-spot; n, o, direction of light; a-c, positions of Euglena with light from n intercepted; c-m, positions with light from o cut off so as to change the direction of the rays. If the ray direction is changed when the Euglena is in position c, there is no reaction until it reaches d. Then it suddenly reacts by bending away from the source of light to e, after which it continues to rotate and reaches position f, where it gradually straightens to g, and rotates to h, when the pigment-spot again faces the light The organism is again stimulated and bent to i, from which it proceeds to j, etc., to m, and it is practically oriented. If the ray direction is changed when the Euglena is at d it responds at once and orients as described above. If the intensity from n is lower than that from o the organism responds at once when the ray direction is changed no matter in which position it is.

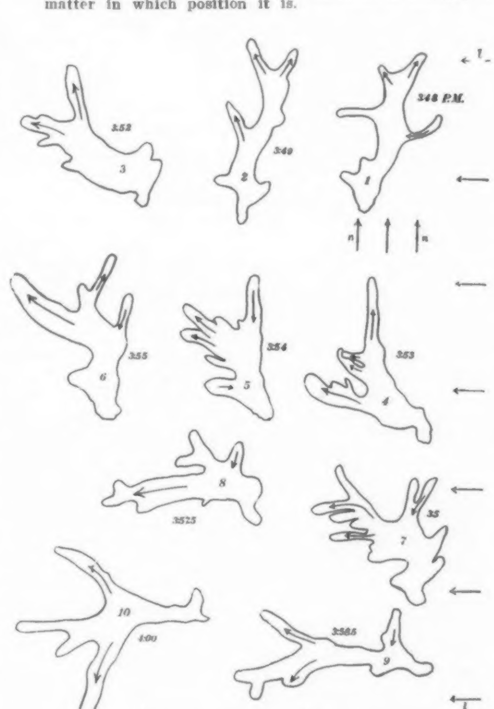


Fig. 3.—Camera drawing representing different stages in the process of orientation in Amoeba proteus.

1. Amoeba oriented in light nn; 2-9 successive positions after exposure to light ll, time indicated on each. Arrows represent the direction of currents of protoplasm in the pseudopods. In those which do not contain arrows there was no noticeable currents at the time the sketch was made. ll and nn, direction and light; mm, projected scale indicating the actual size of the Amoeba.

in light of the proper intensity, not only for their own welfare, but also because of the dependence of many other beings on them for food. And, strange as it may seem, these simple organisms without eyes have the power to do this; when the light gets intense they go down; when it gets weak they swim to the surface. But what interests us mainly at present is how they regulate their movements not only in attaining regions of proper illumination, but also in remaining in these regions. In this respect it is found that different species vary. I shall have time to describe the regulation of movement in only two, one of which is known as Euglena, the other as Amoeba.

Euglenas are small cigar-shaped green organisms, scarcely 0.1 millimeter in length, and but little more than 0.01 millimeter in diameter—quite too small to be seen with the naked eye, but most beautiful creatures as seen under the microscope. Attached to one end there is a thread-like protoplasmic projection nearly as long as the body of the organism, and it is by means of this that the Euglenas swim. During this process the thread-like projection extends forward and has a corkscrew motion by means of which the organisms are literally pulled through the water as they turn on their long axes. Somewhat below the sur-

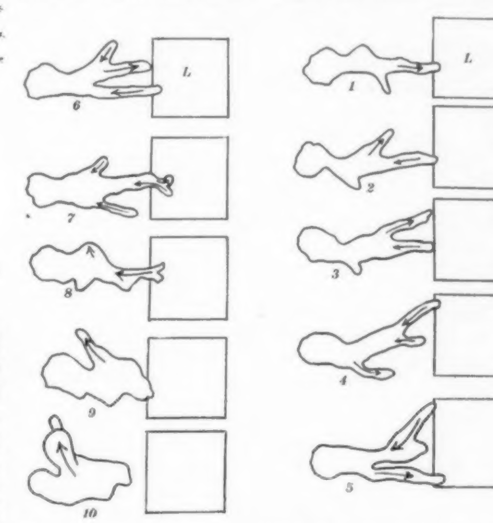


Fig. 4.—Sketches representing the reactions of an amoeba proceeding toward an intense area of light, the rays of which were perpendicular to the slide.

L, field of light formed by focusing a limited section of a gas mantle on the slide. 1-10, successive positions of the amoeba a little less than one half minute apart. Arrows indicate direction of currents in pseudopods.

face near the anterior end there is a small disk-shaped mass of brownish pigment which is opaque to all of the shorter waves of light, the green, the blue and the violet. Sometimes the Euglenas lose their lash-like projection and then they proceed by crawling on the bottom. In this state, just as in the free-swimming state, they rotate on their long axes as they progress, but they ordinarily move much more slowly. Their crawling rate of movement is seldom more than 0.3 millimeters per minute.

Euglenas are found in great numbers in the open sewers about Baltimore. They usually collect on the bottom frequently in such masses as to give the water a deep green color. If a large number are mounted in a dark field which contains a light area of moderate intensity, they aggregate in the light in the course of a very few minutes, frequently to such an extent as to form a dense green mass. How do they get into this area of light and what keeps them there?

Under some conditions they get into the illuminated area accidentally, that is, by swimming about at random; under others, they orient and swim directly toward the light from all directions. In either case they remain because whenever they reach the edge of the area of light so as to cause a decrease of intensity on the anterior end they are stimulated and consequently stop and turn in another direction. This response is repeated every time they come to the edge of the field. Thus the illuminated area acts like a trap. The Euglenas can get in without any trouble, but every time they reach the edge on the way out they are turned back by the stimulus produced by the decrease of intensity; but how is it that they can orient

*A lecture delivered at the Baltimore convention of the Illuminating Engineering Society.

or turn toward and swim directly into the area of light? Before answering this question let me say a few words more on their aggregation. If in place of having a spot of light of moderate intensity surrounded by a dark field, it is surrounded by intense light, as, for example, direct sunlight, it is found that the Euglenas still collect in the moderately illuminated area. Exposure to very intense light causes a reversal in all their reactions, so that they no longer respond when they pass from regions of higher into those of lower intensity as they formerly did, but just the opposite, and if they orient at all they face and swim toward the darker regions, instead of the lighter, and under such conditions they collect in the weaker light in place of the stronger; the area of moderate illumination acts like a trap just as in the case of the dark field save that now it is an increase in place of a decrease of intensity which prevents the creatures from leaving the area. It is evident that such a reversal in reactions is of prime importance to these creatures. It can be seen even more clearly if Euglenas are mounted in horizontal rays of light from a single compact source. Under such conditions they orient and swim fairly directly toward the light until they have been exposed for some time and the intensity becomes very high, then they turn about and swim as directly in the opposite direction until they have reached and have been in weaker light for a short period, when they become positive again. The tendency under these conditions is also to aggregate in light of moderate intensity.

But let us return to the question of orientation and consider the Euglenas in the crawling state since the free-swimming specimens move so rapidly that it is almost impossible to see the details in their reactions under the microscope. If the light intensity is suddenly decreased after specimens are oriented and moving toward its source, they respond with a definite and specific reaction which consists of a sharp bending toward the ventral surface. Precisely the same reaction is found in the process of orientation. Just what occurs during this process can best be seen by arranging two sources of light so that the rays cross at right angles under the microscope, and then, after the Euglenas are oriented in the light from one source suddenly exposing them to that from the other so as to illuminate one side. Under such conditions the direction of the rays can be rapidly changed through 90 degrees as often as desired by alternately shading the two sources of light. The details in the process of orientation will be more readily understood by referring to the accompanying figure in connection with the following description.

If the ventral surface, the surface opposite the pigment-spot, faces the source of light after the direction of the rays is thus changed, there is no immediate reaction. The Euglenas continue on their course as though no change had taken place until the rotation on the long axis carries the dorsal surface over into a position in which it faces the light. As soon as this surface, the surface containing the pigment-spot, faces the light, there is a definite reaction. The Euglenas respond just as they do when the intensity is decreased, they turn the anterior end toward the ventral surface more or less sharply, that is, away from the source of light, but they continue to rotate so that the ventral surface soon faces the light again, but it is evident, owing to the curvature in the body, that the anterior end is now directed more nearly toward its source than it was when this surface faced the light during the preceding rotation. While in this position, the body is somewhat straightened so that the anterior end is not carried back as far during the following rotation, and when the dorsal surface comes to face the light it is directed more nearly toward its source than it was when the organism was in this position before, as represented in Fig. 2. This reaction is repeated during each complete rotation. Every time the pigment-spot becomes more strongly illuminated the organism responds by bending, and when it becomes shaded the organism gradually straightens out and resumes its normal form again; thus the anterior end becomes directed more and more nearly toward the source of light until the organism reaches an axial position in which the pigment-spot is no longer exposed to sufficient changes in illumination during the process of rotation to cause a bending reaction. The organism therefore continues in this direction, that is, more or less nearly toward the source of light. Orientation is frequently brought about in two or three rotations. It is clear that during this process light does not act continuously as an orienting stimulus. The organism responds with reactions leading to orientation only when the dorsal side is turned toward the source of illumination, not when the ventral side is exposed. And it should be emphasized that the first movement in the response is a *bending away from the source of light*, toward which it later becomes oriented.

It is evident from the above description that turning into such a position that the pigment-spot faces the source of light produces a stimulation which results in a definite reaction. In this reaction the organism always bends the anterior end toward the ventral surface. It appears at first thought as though this reaction were due to the illumination of the pigment-spot. This is, however, not true, for, as pointed out above, the response which leads to orientation is precisely the same as that caused by a decrease in illumination without any change in the direction of the rays. It appears probable, then, that the orienting response is due to a decrease of intensity of some sort. It is known (1) that the anterior end of the Euglenas is more sensitive than the rest of the body; (2) that the shorter waves of the spectrum are most efficient in stimulating them; and (3) that the pigment-spot is opaque to these rays. The orienting stimulus is probably due, then, to the decrease of intensity on the anterior end caused by the shadow of the pigment-spot when this is turned toward the light, not to the illumination of this spot.

It is assumed that many of the responses of this organism to light are rooted in the effect of light on the process of photosynthesis—the synthesis of complex chemical compounds in light. This, as previously stated, takes place only in connection with chlorophyll. Euglenas swimming into a shadow, however, respond and turn back into the light as soon as the anterior end which often contains no chlorophyll becomes shaded, that is, before the green part which has to do with photosynthesis reaches the shadow at all. If the assumption is true, it is evident then that this organism, like the wise among its more complicated relatives, the human beings, does not live and act entirely in the present, nor does it respond entirely with reference to the past and present, but also with reference to the future. It is not primarily interested in avoiding the condition of illumination which induces the response, but it is interested in avoiding the condition which would follow if it did not respond when it does. It is of no apparent importance to the organism to keep the colorless anterior end illuminated, but it is of the greatest importance to keep the green part back of this end in the proper intensity of light. All of the reactions are, however, no doubt associated with chemical changes within the organism. Just what these chemical changes are and how they are regulated are fundamental problems for the scientist of the future.

I shall refer only very briefly to the movements, particularly the movements which result in orientation of the organism known as Amoeba. An Amoeba consists of a minute mass of jelly-like protoplasm, rarely large enough to be seen with the naked eye. It lives in slime on the surface of stagnant water or in ooze at the bottom, and feeds largely on bacteria and microscopic green plants, which it engulfs entire by flowing around them. It is all mouth; feed may be taken in practically anywhere on the surface.

It has no locomotor appendages, but flows or rolls along over the surface on which it moves, sending out blunt projections called pseudopods, and withdrawing them as it proceeds, as represented in Fig. 3. Distinct protoplasmic currents in the direction of locomotion are clearly seen during this process. The pseudopods appear to be formed by a weakening of the surface at the point of formation and a consequent rapid flow in that direction. Concerning the mechanics and regulation of the movement in this creature but little is as yet known. But it is known that it responds to touch, electricity, chemicals, heat, light, etc.

Amoebas contain no chlorophyll. They tend to avoid light, especially if it is strong. If exposed to direct sunlight they orient fairly accurately and move from the source of light. The reactions involved in the process of orientation as seen in a given individual are accurately represented in Fig. 3. By referring to this figure it will be seen that when, without changing the light intensity, the direction of the rays is suddenly changed so as to illuminate one side of the creature, all movement toward this side is inhibited, and gradually more and more pseudopods are sent out on the opposite side, until the organism is oriented and moves from the light. The inhibition of movement on the illuminated side is no doubt due to the increase of the light intensity there. Just why this should cause cessation of movement except in so far as it may be injurious is not known. And there is no evidence indicating that it is injurious, for after a few moments' exposure, even in very strong light, movement usually begins again. If intense light is thrown on active specimens all the movement in the whole organism stops at once. This is particularly marked if the light is rich in the shorter rays. Red and yellow have very little effect on the movement. After a few moments' exposure currents are again seen in the protoplasm, and the creatures gradually become active.

In closing I wish to call your attention to an interesting point brought out in the reaction of Amoebas in avoiding intensely illuminated areas as represented in Fig. 4, which shows the process as seen in an individual sketched at the time of observation. By referring to this figure it will be seen that after one pseudopod came in contact with the illumination and was stopped, the Amoeba did not at once proceed in the opposite direction so as to avoid the light, but sent out other pseudopods at only a slight angle with the first, apparently trying to get around the object in its way. The character of the response did not change after the first pseudopod came in contact with the light, nor did it change after the second and third came in contact with it. But after the fourth became exposed the direction of motion was nearly reversed. This indicates that the reaction was modified, that after having been stimulated in a given way a few times the creature changed its method of response. Or, to put it in popular language, after the organism had made several attempts to avoid the light in going in a given direction and failed, it tried another direction. A change in response of this sort is what is usually observed in higher animals during the process of learning; and while I do not wish to be understood as advocating that Amoebas, naked specks of protoplasm, can hope to attain much honor or glory in the way of scholarship, their reactions seem to indicate that they possess at least some of the fundamentals necessary to attain knowledge.

Effects of Ultra-violet Rays Upon the Eye

Prof. F. Terrien of the Medical Faculty of the University of Paris and ophthalmologist to the Children's Hospital writes in the *Revue des Sciences* on this subject.

From staring at a strong electric light, or from glancing at the sun we experience the familiar dazzling and momentary blindness which has been called electhic ophthalmia. The same effect is produced after prolonged exposure to sunlight reflected from snow or ice, or too strong artificial illumination by electricity, and by a strong electric spark, as when a strong current of electricity is short-circuited. In addition to the other symptoms, Dr. Terrien notes, in extreme cases, a sensation of redness continuing for varying lengths of time, photophobia or a shunning of the light, and contraction of the eyelids. From a physiological point of view the various effects are classified by him as: 1, vascular; 2 functional; and 3, nervous.

1. Among the vascular effects are inflammations of the eyeball and of the eyelids, with the occasional formation of a cataract.

2. Functional disturbances show themselves in a narrowing of the field of vision, and a reduction in the sharpness of images. These occur generally in addition to the sensation of redness and the dazzling.

3. The nervous effects are most varied. The increased irritability of the retina shows itself in the photophobia. There may be a persistent pain in the eyeball, and continuous or periodic neuralgic pains. On the motor side, there may be excessive winking and failure of the iris reflex to light—or, the reflex may even be reversed, or inverted! On the side of secretion, there is the excessive production of tears.

From his observatons Prof. Terrien has come to the conclusion that electric ophthalmia, often exhibited by those working under artificial illumination, is caused by the ultra-violet rays, in which the electric light is especially rich. Although glass absorbs these rays, it does not do so completely. He cites the experiments of Birch-Hirschfeld especially to show that these destructive effects may be traced to the ultra-violet rays. In these experiments electric lights were used. When the eye of the rabbit was protected against ultra-violet rays there were none of the pathological symptoms. When the screen was not used, there was disintegration of the chromatin in the ganglionic cells, and disintegration of the pigment in the retinal cells.

Various kinds of glass have been recommended to exclude the ultra-violet rays, as a protection to electrical workers and also for those who have to work under artificial illumination. Dr. Terrien recommends as the best screen a solution of aesculin in 5 per cent gelatine solution; this is to be poured on glass, and after it has dried, to be covered with another sheet of glass. This preparation will absorb absolutely all violet and ultra-violet rays.

Practical Application of Meteorology to Aeronautics—I

What the Meteorologist Can Do for Flying and Airshipping

By W. H. Dines, F.R.S.

THE air is a gas, or rather, a mixture of gases together with an indefinite amount of water vapor. The water vapor plays an unknown part in the production of wind, and is responsible for the rain and snow which may add a very appreciable load to a balloon; it is perhaps the most important factor in meteorological phenomena, but there is not space to deal with it here.

In text-books on physics the following distinction is drawn between a gas and a liquid. A liquid when put into a vessel occupies a definite part of that vessel, but no matter how small a quantity of gas is put into a closed vessel, it will expand and occupy the whole of the vessel.

It has been said that a cormorant always has room for just one more fish, and equally there is always room in a closed vessel for just a little more gas, provided the vessel is strong enough to stand the strain and sufficient force is available to press more in. A given weight of air will always adjust the space it occupies to the pressure to which it is exposed, and it is this property which separates a gas from a liquid, and it has a most important bearing on the behavior of the atmosphere. The power of the air to support a balloon or a flying machine depends upon its density, that is to say, on the actual quantity of gas divided by the volume it occupies. The layers of air near the earth's surface are squeezed together by the weight of the air above them; more gas, therefore, occupies the same space, or in other words, the density is greater than it is above. From this property of air it follows that there is no precise upper limit to the atmosphere. If air were of the same density throughout, it would reach to a height of about five miles, but as it is there is still some air left at a height approaching 200 miles. This is known from the fact that shooting stars do not become visible until their motion is opposed by the air, and since the height of many shooting stars when first seen is found to be 150 miles or more, we know that there is some air at that height, although it must be extremely rarified. Besides their power of adapting the space they occupy to the pressure to which they are subjected, gases possess another property. If a gas is compressed into a smaller space it becomes hot, and when it expands so as to occupy a larger space it becomes cold. This is well known to those who use compressed air for any purpose: Large quantities of water are required to keep the cylinders in which the air is compressed cool, and where tools are driven by compressed air, the tool becomes unpleasantly cool to the hand of the workman.

The relation between the volumes before and after and the corresponding temperatures is given by the formula:

$$\left(\frac{V_1}{V_2}\right)^{.408} = \frac{T_2}{T_1}$$

where T_2 and T_1 are temperatures measured from the absolute zero. Thus if air at the freezing point has its volume doubled its temperature is reduced about 120 deg. F., and if its volume be halved its temperature is raised about 160 deg. F. It has been assumed in the above that the expansion occurs adiabatically, as it is called, that is to say, that the air can neither gain nor lose heat while its volume is changing. This is a condition that cannot be realized in practice so far as air compressors and refrigerating apparatus are concerned, but probably it is very nearly realized in the case where large bodies of air are ascending or descending in the atmosphere, unless the motion be very slow.

This property of air is most important in meteorology; as air comes down from above it is subject to a greater weight of air above it, its pressure is increased, its volume is reduced, and it is warmed. It is a great mistake, but unfortunately even still it is a common one, to think that air from above will be cold because it has come from a cold place. Unless it descends mixed with actual water particles, it will certainly be warm and not cold. It is easy to calculate the change of temperature that occurs with a change of height, and it happens very conveniently that it is the same for all heights in the atmosphere. For dry air or at least for air in which clouds are not forming, it is 1 deg. F. for about 200 foot height; for air in which condensation is occurring it is, under average conditions, at the surface, only half this, namely, 0.5 deg. F. for 200 feet. It is owing to this that the mountains are cold, and to this cause almost every drop of rain that falls is due, for in the constant interchange of air that goes on the air met with at the top of a mountain has recently risen from the plains, and has thereby been made colder than it was when on the plains. If too it chanced to be damp air before it rose the process of cooling will have condensed its moisture and have produced rain or snow.

Our knowledge of the atmosphere has been greatly increased of late years by means of balloons and kites; especially by the former; since the small balloons that are now regularly sent up carrying recording instruments with them reach on the average a height of 10 miles and occasionally a height of 15 miles.

From the information thus obtained I am able to give you the following particulars. The values refer to England, but hardly differ from those obtained on the Continent. At the surface the mean density of the air is such that one cubic foot of it will weigh 1¼ ounce, but owing to changes in the temperature and in the height of the barometer this value may be increased or decreased by some 10 per cent. The mean annual temperature in England is close to 50 deg. F. At a height of one mile the density will be about 82, if we take 100 to represent it at sea level, and the temperature rather over the freezing point. At two miles the density is about 66 and the temperature about 20 deg. F. At five miles, and this is about the limit that man has ever reached, the density has sunk to about 35 and the temperature to a value that will probably be beween —20 and —60. Up to five miles there is certain to be a steady decrease of temperature, but somewhere between five miles and nine miles high a point will be reached beyond which the temperatures will cease to fall. The usual height of this point is seven miles, and the usual temperature is from —50 F. to —70 F.; but the temperature may be as high as —40 or as low as —90 F. At about 15 miles our knowledge from direct observation ceases, but at this point the density is reduced to about 3½ on the scale, and barely one-thirtieth of the whole atmosphere remains above. The temperature is probably about —60 deg. F.

So far as aviation is concerned we hardly need trouble about the conditions that prevail beyond a height of two miles. The lift that a flying machine moving at a definite speed can obtain is proportional to the density of the air, and the loss of one-third of the supporting power is somewhat serious, so that flying at a height of two miles is in some ways more difficult than at the surface. Still, the actual resistance to forward motion is less, and a greater lift can be obtained by a compartive small increase of speed, and since the resistance is reduced this can be obtained, provided that the engine is sufficiently flexible to develop the same horse-power and at the same time to run much faster. The decrease of density with height is not therefore so great an obstacle to obtaining great heights as one might suppose, and it admits of greater speed. The fall of temperature appears to be a more serious obstacle. The given temperature of 20 deg. F. at a height of two miles is the mean for England; the actual temperature on any given date will depend on the season, whether summer or winter, and is also subject to large casual variations just as it is at the ground level. Temperatures between 0 deg. F. and 50 deg. F. have been recorded by balloons at this height. The low temperatures increase the density and lessen the viscosity of the air, but these advantages are probably very small in comparison with the general inconvenience caused, and with the necessity for thick and therefore heavy clothing.

Apart from the change of density with height, changes occur from the varying height of the barometer. At sea level in England the barometric pressure may easily vary from 29.00 to 30.50 inches. This is equivalent to a change of 1,500 feet in altitude. From the practical point of view it is not perhaps a very important amount, but it will undoubtedly be found easier to fly at times of high than at times of low barometer, also at times of high barometer the temperature does not decrease rapidly with height; indeed with a high barometer (anti-cyclonic conditions) the air is sometimes warmer at a height of one mile than on the surface. Also, too, in the event of an accident, there is a rather better chance of its not being so serious at such times, for the denser air checks the velocity of anything falling through it. In the caissons used for building the foundations of the piers of bridges and docks in deep water, where the air is greatly compressed, it is found that men may fall from considerable heights without injury, and did we chance to live on a planet where the density of the air was four or five times as great as it is on the earth, mechanical flight would be quite easy, though the speed of our express trains would be greatly reduced.

But the subject that I more particularly wish to treat is that of wind, for in the practice of aviation it is certainly wind that is the most important consideration. The cause of wind is the unequal heating of the earth's surface by the sun's rays, unequal as between the polar and equatorial regions and unequal as between continental and oceanic regions in the same latitude. The sun's rays pass through dry air and exercise on it comparatively little heating effect, but on reaching the earth's surface they warm it, and it in turn warms the air in contact with it. On reaching the surface of the sea they also warm it, but for three reasons the warming is far less than with the earth. Water is not so readily warmed or cooled as the ordinary rocks that form the earth's surface, and it reflects some of the rays. Also in water the wind and waves cause a continual mixing process to go on, so that a layer of water hundreds of feet thick has to be warmed before much change of temperature is shown, whereas on land it is only a thin layer on the surface that changes its temperature. Still, the constant supply of heat from the sun must tell in time, and the equatorial and tropical oceans are maintained at a temperature of about 80 deg. F. with but little change throughout the year. The oceans in temperate latitudes, the North Atlantic for example, have a larger change of temperature, say, 10 deg. F., between summer and winter, but in the centers and eastern parts of large continents, as in Siberia, the difference between summer and winter may amount to 100 deg. F. Warm air is lighter than cold, and therefore, if we suppose the air to reach to the same height at two places, the place where the air is warm will have a lower barometer than the one where the air is cold. Now to maintain a mass of air subject to a definite pressure, that air must be confined in a closed vessel; but the atmosphere is perfectly free and unconfined, save at its lower surface. Hence it would appear as though these differences of pressure could not be maintained in the atmosphere. As a matter of fact, too, places that are covered by warm air do not always have a lower barometer than places covered by cold air. The rule holds roughly for places in the same latitude, but fails entirely when we compare places in different latitudes. A reasonably good explanation of the general circulation of the atmosphere has, in my opinion, never yet been formulated, and with regard to the more local circulation it cannot be said with certainty whether strong winds and gales are produced by differences of barometric pressure, or whether differences of barometric pressure are produced by strong winds; all that I dare safely assert without fear of contradiction is that the heating of the air by the sun's rays, directly and indirectly, is the primary cause of all wind.

Notwithstanding the objection raised in the foregoing, large differences of barometric pressure are found to exist and to continue between places a few hundred miles apart, and in the space between such places a strong wind is always found to be blowing. This wind does not blow as might be expected from the place of high to the place of low barometer, but it blows more nearly at right angles to this line.

Owing to the fact of the earth's rotation on its axis all bodies moving freely on the earth's surface except on the equator, have a tendency to turn to the right hand in the northern and to the left hand in the southern hemisphere. This tendency varies as the sine of the latitude—it is greatest near the poles, least near the equator. The most convenient point about it to remember is that no matter what the velocity or what the direction, after a certain time the same change of angle will have occurred. After twenty-four $\times$ sine λ hours, the body, if it had perfect freedom and remained in latitude λ, would have completed its circle and be moving in the same way as before. Thus in this latitude an east wind if unopposed will have turned into a south wind in a little under eight hours.

It is this tendency that causes a cross wind between two places where the heights of the barometer are different, or if you like to put it the other way, that

causes the variation of pressure between two places between which a cross wind is blowing.

The term "barometric gradient" means the difference between the heights of the barometer at two neighboring places divided by the distance between the places. In drawing a weather chart, all places at which the height of the barometer is the same are plotted on the map and lines drawn through them, which are called isobars. The distance between two adjoining isobars, say, for 29.60 and 29.70, gives the barometric gradient. When the isobars are straight the wind velocity, which is supposed to blow parallel to the isobars, and is called the "gradient wind," is easily calculated, and is strictly proportional to the gradient. If the isobars are not straight, but curved, it is still possible to calculate the value. I believe the formula for this purpose to have been first given by Ferrel, an American meteorologist, who died some 15 years back, and to whose work sufficient credit has hardly been given either here or on the Continent. Lately Mr. E. Gold has tabulated these values in a very convenient form for the use of the Meteorological Office (M. O. No. 190).

When the formula was first given by Ferrel, it was soon found that actual values of the velocity of the wind taken from the records of anemometers did not agree with the theoretical values, but were much smaller. But of late years a large number of observations of the wind have been made at altitudes up to 6,000 feet and more by kites, and in England and the Continent by means of pilot balloons, this last method having been employed extensively by Mr. Cave at Ditcham Park, Petersfield. It is now found from these observations that on the average the velocity of the wind obtained by observation at a height of from 1,000 to 4,000 feet agrees very well indeed with the gradient wind deduced from the weather chart. I would therefore advise anybody who for purposes of aviation requires to know the wind above, to consult the Meteorological Office and to get from them the latest information about the gradient wind, for a barometric chart certainly gives more reliable information than can be obtained from an anemometer at the surface. A study of the weather maps prepared by the Meteorological Office and published daily in some of the newspapers will soon convince anyone of the general dependence of wind on barometric gradient, and it will also show how in the matter of aviation England is handicapped by her weather conditions. The cyclones or depressions that cause strong winds and gales are very much in evidence on the charts, and it will be seen that their usual track is from S. W. to N. E. just off our western coasts. It is seldom that one of any size crosses the Continent, and in consequence there is in general over the Continent what we in England should call a great deficiency of wind. In fact, the windiness of England is a common source of complaint with visitors from abroad.

Wind affects aviation in two ways, firstly by its actual presence and secondly by its steadiness or gustiness.

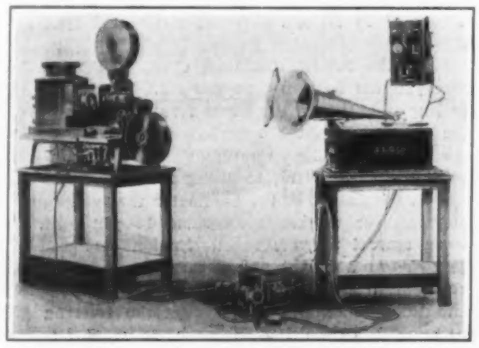
(To be continued.)

European Use of Chemical Fertilizers

In the use of chemical fertilizers in Europe, Germany and Belgium are among the foremost. The use of superphosphates and potash salts has much increased during the last few years, but the nitrogenous products do not appear to have made as much progress. Farmers do not as yet recognize the merits of these latter products as they should. According to the work of Prof. Zacharewicz of the Vaucluse department of France concerning the use of fertilizers for grapevines, it appears that the vines which suffered so much lately from parasites or cryptogamic maladies would have held out much better had his results been known. He finds that chemical fertilizers when judiciously chosen have a complete action upon all parts of the vine. Nitrate of soda, together with sulphate of potash or superphosphate of lime, are found to give the best yields during the tests which have been carried on for the last ten years. In making the choice of the nitrogen to be used for grapevines, it should be employed in the form of nitrate of soda, for the reason that this salt escapes the action of dryness and is directly taken up by the roots of the plant, or the contrary to organic nitrogen. He also finds that the crops obtained by applying the above three salts are improved in quality each year and this in spite of the increased yield. Attention should therefore be given to these results by all those who are interested in vine growing. Another point bears upon the use of fertilizers for potato, beet and also for pasture land. For potatoes, these should be given from 150 to 250 pounds of nitrate of soda per acre, one half after sprouting and the rest later on. Before planting, sulphate of potash should be used at the rate of 150 to 200 pounds per acre. For beets, nitrate of soda is best used at 250 to 600 pounds per acre, according to the nature of the soil. It is applied three times during the growth, in one-third portions. Superphosphate and also chloride of potash are very good for obtaining a large and fine yield, the first at the rate of 500 to 600 pounds per acre and the second at 150 to 200 pounds per acre. As to natural prairie lands whose stock of nitrogen in the shape of black earth is insoluble and not to be taken up by the plants, such lands should receive nitric acid in an assimilable form which allows it to be absorbed at once. Nitrate of soda is again recommended here, using 150 to 200 pounds per acre, along with 400 pounds of superphosphate and 100 pounds of chloride of potash.

The Gaumont Speaking Cinematograph

The Gaumont firm of Paris has produced a speaking cinematograph or "chronophone," by combining a phonograph with the ordinary moving picture apparatus. The apparatus was exhibited at a recent meeting of the Académie des Sciences, and a detailed explantation of the methods adopted for synchronizing



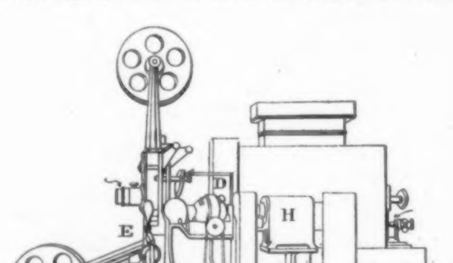
THE GAUMONT CHRONOPHONE

the two machines has been deposited with the Académie, under seal.

A general idea of the apparatus may be obtained from the following description and illustrations, which are taken from *Le Génie Civil*.

In order to record and reproduce, for example, the words and action of a play, it was necessary, not only to secure exact synchronism between the phonographic and cinematographic apparatus, but also to devise a phonographic recorder sufficiently sensitive to register works spoken by actors at a distance, and not even directly in front of the horn. In Mons. Gaumont's first experiments the latter difficulty was evaded by recording the words and the action successively. The actors first spoke or sang into the horn of the phonograph, which then repeated the sounds while the scene was performed in pantomime, the actors timing their actions by the utterances of the instrument. It is better and cheaper, however, to make the two records simultaneously, as the inventor finally succeeded in doing.

Synchronism between the phonograph and the cinematograph is obtained, both in recording and in reproducing, by means of electrical connections between



THE PROJECTING CINEMATOGRAPH

the electric motors which drive the two machines. As it was necessary, for obvious practical reasons, that the entire apparatus should be light and portable, it was impossible to adopt the heavy and bulky synchronizing devices employed in telegraphy (Baudot system), in telephotography (Berlin system), and in fixed apparatus in general.

The two motors are identical in construction, and are operated by the same direct current. Their armatures are divided into sections, and the corresponding sections of the two armatures are connected together. These connections keep the two armatures rotating at the same speed, in spite of small inequalities in the mechanical resistance opposed by the two machines.

In reproducing, the first picture of the film is placed in a certain position and the film is started by the release of a catch (*E* in the drawing), by means of an electrical contact made by placing the phonograph needle at a marked point of the groove traced on the disk. If the synchronism is disturbed by the needle slipping from one groove to the next, or otherwise, the operator starts a small auxiliary motor D_1, which affects the differential connection *D* between the cinematograph and its motor *H*. By this means the motion of the cinematograph is temporarily accelerated or retarded, and synchronism is restored in a few seconds.

It is essential, also, that the reproducing phonograph and cinematograph shall have the same speed as the recording instruments, as otherwise the pitch of the voices will be altered and the action made grotesque. The latter effect is frequently produced, by carelessness or design, in ordinary motion picture exhibitions. A rheostat in circuit with the motors of the reproducing instruments furnishes a convenient means of modifying their common velocity as desired. The handle of the rheostat is shown at *R* in the drawing.

A very powerful phonograph, with several horns through which compressed air is forced, has been designed for reproductions in large halls.

Water Power in Wisconsin

Water-power development in Wisconsin has been put under the control of the Wisconsin Railroad Commission, which already has supervision of many other forms of public utilities in that State. The water-power franchises in the State have been repealed and the holders of them must exchange them within one year for permits limited to 20 years which can be obtained also from the commission for the development of other water powers. The new law provides for levying an annual licensing fee ranging from 20 cents to $2 per horse-power developed, the fee being based on the value of the power. It is evident that the law is a remarkably drastic one on its face, but so has been every other public utility law passed in the State. The fact is, however, that such laws, as interpreted by the Wisconsin Railroad Commission, have proved very helpful, indeed, to those Wisconsin companies engaged in public service work and aiming to furnish good service at reasonable rates. The commission has been more sever, if anything, in criticizing municipal authorities against whom complaints have been made than in its judgments where private companies were defendants. This is not surprising, of course; for municipalities have long held the opinion that they were free from some of the financial and administrative regulations which must be met if efficiency is desired. For many years, for instance, the system of water rates of Madison was held up for the admiration of water boards and water companies everywhere. Criticisms of it at meetings of water-works associations were rebuked as something almost sacrilegious. And yet when that much-advertised system of charging for water was before the State Railroad Commission for a semi-judicial inquiry into its equity and its usefulness it emerged from the trial terribly tattered. The nominally drastic laws of Wisconsin, as interpreted by the Wisconsin Railroad Commission, seem to be about as effective in securing equitable administration of public utilities as anyone can desire, and consequently the operation of the new Wisconsin law respecting water powers will be watched with great interest.—*Engineering Record.*

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